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THE HEART AND THE AORTA

PUBLISHED ON THE FOUNDATION
ESTABLISHED IN MEMORY OF

WILLIAM CHAUNCEY WILLIAMS

OF THE CLASS OF 1822, YALE MEDICAL SCHOOL

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THE
HEART AND THE AORTA
STUDIES IN CLINICAL RADIOLOGY

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TRANSLATED FROM THE SECOND FRENCH EDITION

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THE present volume is the fourth work published by the Yale University Press on the Williams Memorial Publication Fund. This Foundation was established June 15, 1916, by a gift to Yale University by Dr. George C. F. Williams, of Hartford, a member of the Class of 1878, Yale School of Medicine, where three generations of his family studied—his father, Dr. William Cook Williams, in the Class of 1850, and his grandfather, Dr. William Chauncey Williams, in the Class of 1822.

PREFACE TO THE SECOND EDITION

THIS book has been received with such favor by the medical profession that the first edition, published in 1913, was quickly exhausted. We have decided to reprint it, notwithstanding the material difficulties which can well be imagined. We have taken this opportunity to modify some chapters and to add new ones, dealing with the measurement of cardiac hypertrophy by finding the index of depth, with the diagnosis of pulmonary and tricuspid insufficiency, and finally the localization of projectiles of war in the heart and the pericardium. We have tried to keep in this work the practical value which physicians have recognized in the first edition and more especially for those who, having the task of drawing up the "*dossiers de réforme*" for soldiers afflicted with cardiac affections, wished to add to the indications of current semeiology the more precise indications of radiological methods.

February, 1918.

PREFACE TO THE FIRST EDITION

THE semeiology of the cardio-vascular system has been considerably enriched by adding graphic recording and radiology to the old methods of examination, such as percussion, palpation, and auscultation.

Graphic recording has enabled us to analyze with precision the mechanism of the cardiac rhythm, to distinguish its different anomalies, and to refer to arhythmic actions their place in diagnosis and prognosis of diseases of the heart so important and long misunderstood.

More recently radiology has come to take a place beside graphic recording, the importance of which is continually increasing.

At the end of the last century it was not believed that the field of roentgenological exploration would ever pass beyond the domain of surgery. If we considered radiography perfectly capable of determining the exact lesion in the bones, we thought, on the other hand, that it was of doubtful value in the examination of the internal organs. To determine the relation of the lungs and the heart in the different pathological conditions, to judge the state of the pulmonary parenchyma, to give a rough estimate rather than a measurement of the volume of the heart, was all that we then expected of radiography. It did not seem that it could ever accomplish more.

Progress of inestimable value has been made in precise radiology which enables us to obtain normal images of the heart according to the plane of projection or, to state it better, the exact configuration and the true contours of that organ. In the pathological state this configuration and these contours undergo variable modifications, but in direct relation to organic alterations of the heart. It follows, then, that we have a right to diagnose the lesion with which the heart is affected, upon a simple examination of its exterior aspect. This notion, well established

by anatomical proofs, has been until our day only imperfectly utilized in clinics, the processes of exploration being incapable of giving sufficiently precise indications.

Radiology of precision has come to fill this gap. During the life of the patient it shows to the observer the heart as it appears on post-mortem examination, perhaps even less deformed, for it is animated by the circulation. Radiology gives a precise objective description of pathological deformations and reveals the exact exterior configuration of the heart, which warrants our concluding the existence of different organic or valvular lesions.

In spite of their importance, the data relating to these examinations have not yet in France been made the subject of a complete work. It seemed to us therefore that it would be interesting to gather together ideas which have been scattered and to add to them the result of our personal observations.

It is not our purpose, however, to issue a didactic treatise on radiology of the heart and the aorta, so the reader will not find the profusion of bibliographic references, citations, and names of authors which he might reasonably expect in a work of this kind.

Although we are compelled to tell what we have observed and indicate the methods used, we have also set forth the results arrived at by certain authors who have preceded us. When our opinion has agreed with theirs we have not failed to mention it. When we have differed, we have given the reasons, indicating the grounds for our conclusions.

The work which we present today to the medical profession may be useful to radiologists, who will find here the description of the mechanical methods which we have used, as well as to physicians to whom it will furnish indispensable ideas about a method of exploration, a knowledge of which appears more and more necessary.

H. Vaquez and E. Bordet.

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CHAPTER I

RADIOLOGICAL METHODS

WHEN one examines on a fluorescent screen a patient's thorax, one is struck by the clearness of the cardiac shadow. This results from the density of the heart which is relatively opaque to the x-rays, whereas the lungs are freely permeable. So from the very first, the idea arose of using radioscopy and radiography to study the heart, in the normal and pathological state. At first the results were of rather slight importance. Though it appeared relatively easy to estimate the modifications in the volume of the heart, provided they were already sufficiently marked, and to recognize the existence of voluminous aneurismal sacs, one did not feel justified in expecting radiology to give greater precision. Radiology was believed to be radically incapable of furnishing an exact measurement of the cardiac diameters, and of the changes which they may undergo during the course of the same affection. Difficulties which at first were not taken into account constantly occurred, arising primarily from the inadequacy of the methods of exploration and from the perpetually changing conditions of the heart. As the heart is continually in motion within a cavity, of which the limits themselves vary with the act of respiration, the result is that the roentgenological images present extremely diverse forms. It was important, then, before going further, to determine exactly the value and the significance of these variations; but that was realized only gradually and in the course of the last few years.

The first necessity was to modify the technic hitherto employed.

Roentgen rays arising from a luminous source constitute a beam, the radiations of which follow a divergent or conical direction, and from that there results an evident deformation in the contour of projected images. It was necessary to attack the problem of correcting the causes of error due to this deformation of shadows and it will be shown that the problem has been successfully solved. There remain almost no great difficulties in the radiological examination of the heart and the blood-vessels. The technic has been so far perfected that the images obtained have a great degree of accuracy; the interpretation of them, though it may still be open to some dispute, is at least settled definitely in its broad outlines.

Since the question of technic plays such an important part here, it is fitting to present a detailed and critical study. We do not intend to describe the apparatus necessary for the production of x-rays, as we assume it is well known, but we shall try to describe carefully the different radiological methods used in the study of the heart and the blood-vessels, to compare them with each other, and to indicate their respective advantages and faults.

I. RADIOGRAPHIC METHODS

1. *Time Radiography.* This method consists in charging a Roentgen tube of ordinary type with a low current of from 0.5 to 1 milliampere. The patient is placed on his back, the radiographic plate under him; the tube is placed over the sternum, at a distance of 50 to 70 centimeters. The negatives obtained by this method require a prolonged exposure, which results in the contours of the cardiac shadow becoming blurred, owing to the pulsation of the heart and the respiratory displacements of the heart, which are multiplied during the exposure. Besides, the projection is enlarged and deformed to such an extent that it is impossible to correct it. So images obtained by time radiography are records of no value. This method, then, should be rejected.

2. *Instantaneous Radiography.* Of late years, physicists and manufacturers have tried, at the request of radiologists, to construct apparatus and tubes capable of furnishing a secondary current of several milliamperes. This method, called intensive, allows of the passage into the Roentgen tube of 10, 20, 60 milliamperes and even more, during a very short space of time, which can be measured in seconds and fractions of seconds. The quantity of rays produced in this way is enough to impress instantaneously supersensitive radiographic plates. The adjustment can always be made more sensitive by the addition of an intensifying screen. This method constitutes an important step forward. It puts at the disposal of the operator a large amount of Roentgen rays, and the negatives are obtained with very short exposures. Thus it is easy to radiograph the thorax of a patient while in the state of suspended respiration. By this the respiratory displacements are eliminated, and the negatives gain much in clearness. A series of images taken during successive phases of respiration contribute to the study of the relations of the heart and the diaphragm during inspiration and expiration, which is very useful.

In spite of these advantages, the image obtained is deformed as in the preceding method, and if the contours are clearer, the estimate of the dimensions of the cardiac area is still only approximate.

3. *Teleradiography.* To avoid the deformations due to the conic projection of x-rays, Kohler (Wiesbaden) conceived the idea of enabling us to radiograph the heart from a great distance, by causing the rays which arise from the target of the tube to take a perceptibly parallel direction. To do this all that is necessary is to place the tube two meters from the subject, "the rays which form the tangents with the line of the circumference of the heart grazing it at almost equal angles." The parallelism of the rays is not absolute, but the errors of projection are insignificant.

The source of the rays used in such a case must be very powerful. Several types of apparatus of French and American make are capable of furnishing the necessary energy. The choice of a powerful and resistant tube constitutes an important problem. The intensive Pilon and Coolidge tubes, not to mention others, are excellent.

To obtain a radiogram of the heart at a distance, the process is as follows: the patient is placed standing or sitting with his back to the tube, the tube being 2.5 to 3 meters away from him (the distance of 1.5 to 2 meters, recommended by certain operators is insufficient and causes deformations); a fluoroscopic examination is then made to determine the exact position. When this is done, a radiographic plate is substituted for the screen and a negative made, the anterior surface of the thorax being in contact with the plate.

To radiograph the heart and the aorta in oblique positions, the same procedure is followed, only the patient turns so that he forms with the plane of the plate an oblique angle (50 degrees on the average). The rays traverse the thorax obliquely from right to left or from left to right, from front to back or from back to front, according to the requirements of the examination.

The teleradiograms give the corrected shadow of the heart with all its curves and all its angles, constituting, therefore, a real projection of the organ. They show, moreover, the relations of the heart with the skeletal shadows, with the lungs and the diaphragmatic arches, and also afford valuable records for the clinician, who then can measure the total area of the heart, its diameters and outlines, judge the position of its contours as well as the form of the silhouette obtained.

II. RADIOSCOPIC METHODS

1. *Normal Radioscopy.* This method gives a good general view of the thorax and nothing more. When the patient is placed behind the screen of platino-cyanide of

barium and the Roentgen tube is charged, we see the shadows of the mediastinum outlined on the clear borders of the lungs. The heart pulsations are clearly perceived, the respiratory movements are interpreted by the vertical displacements of the heart, by the raising of the ribs and of the outline of the thoracic cavity, and by the lowering and raising of the diaphragm. By rotating the body of the patient from right to left or from left to right, the anterior and posterior mediastinal spaces are shown; these appear clear because of the slight density of the tissues, and it is easy to observe the outline of the denser organs, as well as to discover the additional shadows of pathological origin. Finally, examinations in the dorsal or lateral position complete in a very short time a series of observations of the thoracic shadows as a whole.

This method, then, gives general information about the regions x-rayed, about the relations and the forms of the shadows, but it does not furnish any precise information about the real dimensions of the organs; nothing more, indeed, than the amplitude of the movements which animate them.

2. *Orthodiascopy.* To correct the deformations of Roentgen projections, radiologists have from the beginning suggested an arrangement by which, by moving the tube to a convenient distance, the organ under examination should be made visible only at a point where the central beam of rays, emanating from the focus, traverses it perpendicularly to the plane of the screen. In this way, the normal ray being tangent at a determined point, the projection of this point is real and deformation no longer exists. If, for example, the normal ray is directed at a tangent to the apex of the heart, the shadow of the apex corresponds to its exact position in relation to the screen and to the body of the patient. In executing the same movement to determine the location of the right cardiovascular angle, at the base of the heart, a new point of the organ is marked, and if the experiment is repeated

with all points which lie on the contour of the cardiac shadow, the result is an accurate projection of the heart on the radioscopic screen.

The diagram in Fig. 1 shows the differences of projection obtained when the tube remains at a fixed point or when it is moved according to the orthodiascopic method.

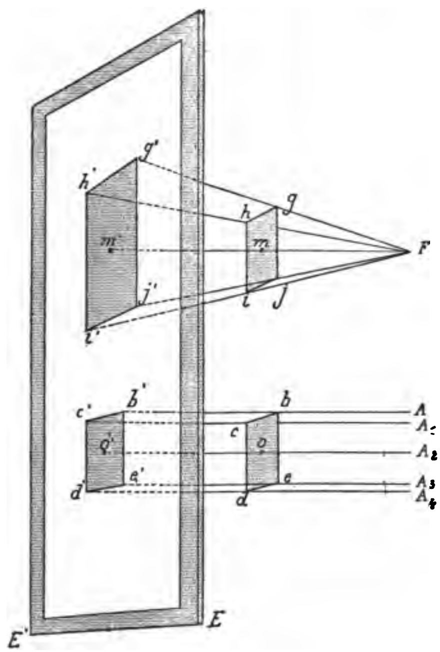

FIG. 1. DIAGRAMS OF ROENTGEN PROJECTION

Above, conic projection: F, focus; F *m*, normal ray; *g h i j*, object; *g' h' i' j'*, projection of the object; E, E', screen. Below, orthogonal projection: A, A_1, A_2, etc., foci occupying different positions, so that the normal ray, A *b*, A_1 *c*, A_3 *e*, A_4 *d*, is successively tangent to the angles of the object, *b c d e*. In *b' c' d' e'*, projection obtained by this method.

If the tube is immovable at F, the normal ray, F *m*, is directed toward the center of the object, the beam of rays emanating from the focus traverses divergently the object, *g h i j*, and projects its image on the screen at *g' h' i' j'*.

The contour of the shadow obtained is much greater than the contour of the body exposed to the rays. It will be noticed that the normal ray follows a direction perpendicular to the plane of the screen; in *m* and in *m'*, it is in the geometrical center of the object and of its shadow. The projection of *m'* is therefore normal; but around this point the rays diverge more and more; the image is enlarged in proportion as the region under consideration is distant from the center, *m'*. The figure, *g' h' i' j'*, consequently, does not represent a proportionate enlargement of the opaque body, but a deformed image of it.

If the x-ray tube is movable and can be shifted on a plane parallel to the plane of the screen, there is nothing to prevent its being brought to position A, so that the normal ray shall be tangent to one of the angles of the object, *b c d e*, and shall follow, for example, the direction A *b*. This ray, or at least those immediately contiguous, passing the opaque body, will strike the fluorescent screen perpendicularly in the neighborhood of point *b'*, this point being the shadow of the angle *b*. It is easy to mark this point *b'* with an oil crayon on the glass of the screen. By shifting the tube successively to A_1, A_3, A_4, the angles, *c' d' e'*, of the shadow are determined, which correspond to the angles *c d e* of the object. It is evident that if these points of the shadow are connected by straight lines, a figure is obtained, the dimensions of which are exactly the same as those of the object.

If, then, in a radioscopic equipment we possess means of moving the tube horizontally and vertically on the same plane, and if, moreover, we have an especial adjustment (formed by crossed wires over the diaphragm in the center of which passes the normal ray) by which we can know the point where the normal ray strikes the screen, it is possible to determine the different regions of the cardiac shadow to which the normal ray is tangent.

3. *Orthodiagraphy.* The method which consists in outlining the contour of the shadows according to their

normal projection is the orthodiagraphic method. The orthodiagrams are constructed on the principle which we have just studied: continual estimation of the normal ray and of its point of projection on the screen, perfect mobility of the tube allowing the passage of the normal ray over the entire surface of the screen.

Orthodiagrams are of different models. They are all open to criticism; the best is that which each individual is accustomed to use. It is not enough to have an orthodiagraphic apparatus; it is necessary to have acquired a certain dexterity. Some preparatory training is necessary to avail oneself of all the advantages which this method offers. Physicians who, in our opinion, depend too much on the mechanical means of investigation, condemn orthodiagraphy because of the effort which it requires of the clinician, aside from the study necessary to interpret the outlines. The early difficulties of the method are soon overcome and give results which prove the accuracy of the investigator's observations.

The first orthodiagraphic apparatus was constructed in Germany. Moritz was the first to show the importance of the records which orthodiagraphy gave relative to the pathological modifications of the volume of the heart. The principles of the method were applied with the same success by Levi-Dorn, Grünmach, Groedel, etc., who constructed apparatus which differs in manipulation and the methods of recording, but which answers the same general purpose.

It is not necessary to study these types of apparatus; a description only of the orthodiagraphic apparatus of Destot which is used in France will be given.

This apparatus consists of a movable holder, one of the arms of which carries the tube with its diaphragm, the other the small recording screen, or, in the more recent models, the recording crayon. This holder is mounted on a double joint counterpoised and so regulated that the whole system is in equilibrium.

Behind the screen and parallel to it is fixed a frame of wood; on that is placed a block of paper on which the tracing is made. A crayon, held in the center of the screen, is jointed in such a way that it can be lowered to touch the sheet of paper, through a little opening arranged in the middle of the screen. The adjustment of the apparatus is made in such a way that the point of the crayon is always in the prolongation of the normal ray, perpendicular to the plane of the screen and of the block of paper. When the small recording screen is not there, the crayon remains at the extremity of the holder which faces the tube, while the frame which holds the paper is replaced by a large screen, and the tracing is then made on the glass or on a small sheet of celluloid paper fixed on the screen.

To take an orthodiagram, the procedure is as follows: the patient is placed standing, behind the fixed frame, in the position desired (frontal, for example, that is, the anterior surface of the thorax against the frame), and held in place by means of crossed straps. The current is turned on to the tube, and the thoracic image appears on the screen. As the crayon is moved, the tube is moved equally, for the two systems are coördinated; so that when the point of the crayon follows the contour of the shadow of the heart, the heart is made visible by a beam of x-rays, of which the normal ray is tangent to the outline of the organ. By drawing the whole length of the shadow outline, the contour of the exact projection of the organ is traced. Orthodiagrams thus obtained are quite sufficiently precise when all the conditions of the experiment are minutely observed. Errors of technic are insignificant; they vary from one to four and sometimes five millimeters.

The orthodiagraphic apparatus of Destot can be placed in all inclinations between the vertical and the horizontal and so permits the examination of patients, as may be required, standing, sitting or lying. Moreover, the trac-

ing of the outline can be made directly on the thorax of the subject.

In order, however, to practice orthodiagraphy it is not necessary to possess a special apparatus. Some of the apparatus of normal radioscopy can be used for orthodiagraphy. It is enough to realize these essential conditions: lateral and vertical movability of the tube in the same plane; absolute immovability of the screen in a plane perpendicular to the normal ray. But it is necessary that the operator be able easily to move, with his left hand, the control of the tube and of the diaphragm, in order that the right hand may be free to make the tracing; it is advisable, besides, that the screen should slide vertically in a rigid support and should be fixed at variable heights.

We have given up the use of a screen rigidly connected with the tube and no longer trace blindly on a block of paper. We work on the lead glass of a large screen. The estimating of the normal ray is done by means of the diaphragm-iris. By reducing the rays to a small circular field we know that the normal ray is situated in the center of the luminous zone. To that point we bring the part of the outline which interests us and we mark on the glass, at the level of the shadow, a line with a broad crayon. By increasing and diminishing alternately the luminous field, the observer recognizes clearly the area which he is studying and its relation to neighboring regions. Moreover, the results can be easily verified, and by successive trials it can be proved whether the crayon marks and the cardiac outline coincide exactly; also the slightest displacement of the patient can be noticed and errors corrected. Correction is so easy and so rapid that it becomes useless to strap the patient, and this shortens the operation and allows a quick shifting to the different positions for examination. When the operation is completed, to transfer the tracing to transparent paper takes but a moment.

4. *Teleradioscopy.* Radioscopy from a distance, or teleradioscopy, offers the advantage of throwing on a screen the shadows of the thoracic organs with their real dimensions.

The technic is extremely simple. All that is necessary is to place the patient before the screen in all the positions necessary for examination. The radiologist has only to trace on the lead glass the contour of the cardiac shadow without going through any process of correction.

III. PERSONAL TECHNIC

This is the technic which we employ at *l'hôpital Saint-Antoine.*

We use a powerful installation with a direct current of 110 volts, and a coil of 50 centimeters. With this apparatus we can practice orthodiagraphy, teleradioscopy and teleradiography. A special device facilitates the successive examinations to which the patients are subjected.

These examinations are as follows: we begin with fluoroscoping the thorax as a whole; then, by moving the tube, we explore the different parts of the cardiac or aortic shadow which interest us; we study the pulsations and the respiratory play of the shadows. After this preliminary examination, we take one or several orthodiagraphic tracings in the most favorable positions.

When it seems to us opportune to make an x-ray plate of the most characteristic image, we place the patient away from the tube at a distance of at least two and a half meters. The distance of one meter, a meter and a half or even two meters gives too considerable deformations. It is only at two meters and a half that the enlargement is reduced to its practical minimum; the projection of an object fifteen centimeters in size is augmented by only four or five millimeters, figures which correspond to the errors of technic accepted in orthodiagraphy. It is necessary that the tube be properly

centered on the region to be studied. When it is a question of the heart, for example, this is the procedure: we illuminate the radioscopic screen and by means of a diaphragm with a circular opening we so adjust it that the image of the heart is exactly contained in the interior of the luminous circle, the diameter of which should correspond exactly to the greatest diameter of the heart. We then fix the patient and the tube in their respective positions; we give the diaphragm a greater opening, we place a plate instead of the screen or between the screen and the thorax and set the apparatus in action.

As to *teleradioscopy*, we make less and less use of it.

It gives precise evaluations when the patient is in a direct position, especially the direct anterior, in which the thorax is maintained in contact with the screen. It is not at all the same in oblique positions; the distance of certain parts of the organs examined amplifies the shadows and deforms them in part. Moreover, since the teleradioscopes necessitate a prolonged intensive use of the tubes, these deteriorate rapidly. Finally, the control of the tube and the diaphragm is difficult at a great distance, with the result that the operator is but poorly protected against the rays which forcibly overspread the lead glass of the screen.

IV. COMPARISON OF METHODS

A certain number of these methods are incapable of giving precise information; these are the methods which do not permit the exact reproduction of the dimensions of the objects according to their plane of projection. Radiography at short distance is in this class; it furnishes only useless stereotypes, because the shadows of the organs are deformed, which too often lead to gross errors. It is therefore necessary to reject this method because the sometimes contradictory data furnished have proved confusing to clinicians and it is all the more important to insist on this. It is necessary to make the clinician under-

stand that his misconception arises from the defective use of investigative methods and that besides simple radiography, which can give erroneous results, there are other radiological methods which are quite reliable.

These methods, three in number, are: teleradiography, orthodiagraphy, and teleradioscopy. The last two are identical in the information which they furnish and are designated here by the term radioscopy of precision.

Teleradiography and radioscopy of precision have each its advantages. The association of the two methods is nearly perfect; but if one only is to be used, then an orthodiagraphic examination leads to a more precise diagnosis than a teleradiographic plate.

The great advantage of radiography is to procure one or more radioscopic records of the heart shadows, blood-vessels, neighboring organs and the thoracic skeleton. Moreover, these shadows have the actual proportions of the organs which they represent according to their plane of projection; finally the value of the shadow is proportional to the density of the tissues. Taking several plates in different positions multiplies the advantages of teleradiography. Plates can thus be interpreted and discussed by physicians in the absence of the patient, without recourse to successive verifications. All this constitutes the superiority of teleradiography over simple radiography, but does not exclude the advantages of radioscopic methods.

Orthodiagraphic tracings, which for the sake of simplicity are called cardiograms, give an exactness as great as teleradiograms, and the exact measure of the shadow of the heart. But the great advantage of radioscopy of precision is to allow the observation of pulsations and of the displacements of the heart itself and their modifications according to the varied position of the patient. Finally, precise radioscopy alone is capable of giving information on the following questions, the full importance of which will be seen in the course of this work:

(1) respiratory displacements of the heart; (2) movements of expansion of the diaphragm; (3) mobility of the apex of the heart; (4) respiratory outline of the thorax; (5) evaluation of the volume of the left auricle; (6) pulsations of the right ventricle; (7) determination of the position of the left ventricle at the base (point G); (8) determination of the angle of disappearance of the apex in the right posterior oblique position; (9) measurement of the ventricular development in depth.

Radioscopy of precision has, then, one point of superiority over teleradiography, that is, it produces the greatest amount of information in the shortest time. One may urge against it that its records do not guarantee impersonal evidence as offered by radiographic plates. But whether one or the other of these methods is used, no protection is afforded from causes of error which ought to be logically absent from every record called impersonal. The part played by observation is still considerable. The personal factor intervenes at every instant in the taking of a radiogram, in the position of the patient, in the centering of the tube and the placing of the plate. These different operations necessitate an experience and an ability which are not common to all. The proof of it is that the physician, before interpreting a record, does not fail to inform himself of the conditions under which it was made.

Moreover, for studies in cardiac radiology, the ideally impersonal record would not do.

An impersonal record is a dead record. If it gives evidence of a foreign body, the existence of a fracture, the conformation of a tumor, it has not the power to interpret the life of an organ perpetually in motion. When it is a question of the heart, its life is manifested by the energy of its pulsations, the extent of its displacements, the density of its shadows; when one examines an artery, it is extremely instructive to note the amplitude of its pulsations, the flexuosity of its contours, the degree of

transparency or opacity of its walls. To know all that, requires a competent observer.

But let no one misunderstand our opinion. We do not pretend that radioscopy of precision constitutes the only process of examining the heart and the aorta. As we have already said, we believe that radioscopy procures the greatest amount of useful information. The radiographic record is secondary, but it is evidently incomparable for fixing by radiographic proof one or several exposures at intervals.

Moreover, whichever of these processes of precision we employ,—orthodiagraphy, teleradioscopy, teleradiography,—we shall none the less be in final possession of the contour of the shadows of heart and blood-vessels, that is to say, of a cardiogram to be analyzed.

It is, consequently, the interpretation of radiological images of the heart which will comprise the substance of the following chapters.

CHAPTER II

THE SHADOW OF THE HEART IN ITS NORMAL STATE

I. POSITIONS OF THE PATIENT—DEFINITIONS

THE shadow produced by the heart on the fluorescent screen varies according to the position of the patient. Therefore, to have images comparable with each other, permitting the methodical study of the contours of the organ as well as its relations with its surroundings, it is indispensable to define, first of all, the different positions for the study of the images desired.

Theoretically, in order that the information be as exact as possible, the patient ought to be examined in all the positions through complete rotation. But such a procedure is superfluous. It is sufficient to take the radioscopic image at certain intervals to have all the indications required. These different intervals correspond to typical positions, in which it is expedient that an image should be taken.

These positions are first *the direct position,* called *anterior* and *posterior,* according to whether the examination is made from the front or back, then all the intermediate positions, *oblique,* and *lateral, right* or *left,* according as the patient in rotating presents to the fluorescent screen first the right shoulder, then the back, then the left shoulder.

1. Direct Positions. The direct positions are two in number: the frontal position or direct anterior, and the dorsal position or direct posterior.

(a) In the *frontal position* or direct anterior, the pa-

tient faces the screen and the operator (radioscopy), or the radiographic plate (radiography). In this position he turns his back to the tube; the rays penetrate the posterior surface to the anterior surface of the thorax (dorso-ventral direction).

(b) In the *dorsal position* or direct posterior, the patient turns his back to the screen or the plate, and the rays follow an antero-posterior direction (ventro-dorsal).

In these two positions patients can be examined standing, seated, or recumbent. The information obtained is of the same absolute value, on condition, however, that the position of the body be well specified, for the image of the heart is modified accordingly.

In medical practice the choice of position is sometimes imposed by the condition of the patient. Certain cardiac patients suffering from dyspnœa cannot accommodate themselves to the prone position, others cannot keep the standing position. Besides, each of these positions offers special advantages.

Examination in the prone position is recommended for two principal reasons: (1) the subject is perfectly immobile; (2) the orthodiagraphic findings are exactly comparable to the findings by percussion which one generally takes in the same position (with the patient in bed).

Examination in the upright position is convenient for the rapid observation of the patient in all positions. By making him rotate, the observer places the patient successively in the frontal, dorsal, lateral, and oblique positions. During these movements the progressive changes of the shadows are noted and, what is not less important, the relation of the projection of the heart with the vertebral column, the thoracic walls, the blood-vessels, etc. The oblique examination is practicable only in the standing position. When in this same position one takes the frontal outline of the heart or a radiogram of it, it is important to have the patient completely immovable. The lateral movements of the body, even those that are

involuntary, are the most frequent. They can generally be avoided by holding the anterior region of the thorax against the screen or, if need be, by fixing the shoulders by means of crossed straps.

The seated position gives information identical with that in the vertical position, provided that the patient rests on an elevated stool and that the trunk is held upright.

2. Oblique Positions.

(a) *Right anterior oblique.* In this position the patient faces the operator or the plate; his *right shoulder* is against the screen or the plate, and the plane of the body describes with the plane of the screen or the plate a more or less wide angle.

(b) *Left anterior oblique.* The patient faces the operator or the plate, the *left shoulder* against the screen or the plate.

(c) *Right posterior oblique.* The patient turns his back to the operator or to the plate, the *right shoulder* against the screen or the plate.

(d) *Left posterior oblique.* The patient turns his back to the operator or to the plate, the *left shoulder* against the screen or the plate.

3. Lateral Positions. The patient describes with the screen or the plate an angle of 90 degrees, the *right shoulder* against the screen or the plate. It is then in right lateral position. Inversely, if the *left shoulder* is in contact with the screen or the plate, the position is left lateral.

II. STUDY OF THE IMAGE OF THE HEART IN ITS PRINCIPAL POSITIONS

A. IMAGE OF THE HEART IN THE FRONTAL POSITION

The subject of study, in the following descriptions, will be the projection of the shadow of the heart obtained by orthodiagraphic tracings. It is self-evident that these

observations would apply equally well to the image obtained by long distance radiography, because the two processes furnish identical images, not deformed, which is of primary importance, and which could not be realized by other methods.

FIG. 2. HEART IN FRONTAL POSITION

In order to understand the meaning of orthodiagraphic tracings it is necessary to know, first of all, the anatomic image of the heart in the frontal position. This is reproduced in Fig. 2.

It will be seen that the right ventricle occupies the greater part of the diagram. It is bounded above and at the right (left in the figure) by the auricular-ventricular groove that separates it from the right auricle, which constitutes the upper two-thirds of the contour of the organ.

On the left side (the right of the figure) the anterior inter-ventricular groove bounds on the outside a narrow band of the left ventricle from the base to the apex. The left outline of the organ is, then, in its whole length the left ventricle. At the base the aorta and the pulmonary artery arise, whose respective directions soon cross.

In tracing on a record the contour of this anatomical figure, we obtain the outline of Fig. 3.

On the *right* (left of the figure), in the fourth intercostal space, the right ventricle; in the third space, the

right auricle; in the second space, the edge of the sternum behind which are the ascending aorta and the superior vena cava.

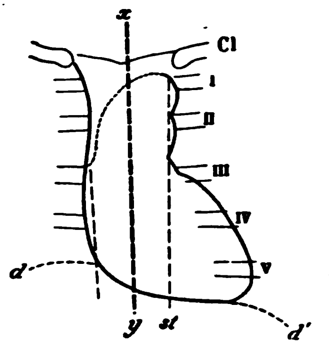

FIG. 3. SCHEMATIC RECORD OF THE CONTOURS OF THE HEART

On the *left* (right of the figure), in the first space, the contour of the arch of the aorta; in the second space, that of the pulmonary artery below which is the left auricle; in the third, fourth, fifth spaces the left ventricle.

In Fig. 3 we have indicated the outline of the clavicles (*cl*), of the sternum (*st*), and of the ribs.

The study of the radioscopic image of the heart in frontal position, is as follows.

Contours. If one follows the contour of the median shadow of the thorax (Fig. 4), one observes at the left of the figure, starting from the right diaphragmatic dome, a curved line, D′D, which circumscribes the right auricle. Above point D the contour follows straight up as far as the sterno-clavicular articulation, thus giving the outline of the sternum; but in the case of many patients, otherwise normal, the ascending aorta runs slightly over the sternum and the shadow presents a projecture, not strongly accentuated, following the line DA.

If we pass to the right side of the figure, that is, to the left side of the patient, the contours of the median shadow present three semicircular salients or three superimposed arcs: the superior or aortic arc (A′A″) due to the out-

line of the descending portion of the arch of the aorta; the middle or pulmonary arc (A″G) due to the salient of the pulmonary artery, below which is seen another small salient which corresponds to the left auricle; finally the inferior arc (GG′) made by the outline of the left ventricle from the base to the apex. This last is very near the left dome of the diaphragm.

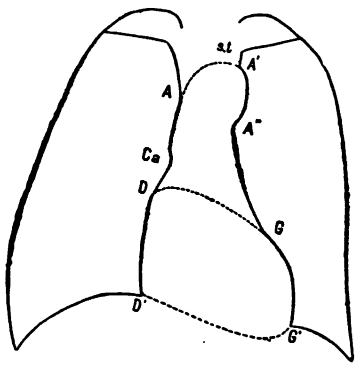

FIG. 4. ORTHODIAGRAM OF THE HEART AND THE LARGE VESSELS IN FRONTAL POSITION

Particularly interesting contours for the study of the normal or the pathological heart are found between letters DD′ and GG′.

The line DD′ defines in the normal state the contour of the right auricle. However, it may happen that, in certain patients, during radioscopic examination, clear pulsations are perceptible in the neighborhood of point D′. These are systolic pulsations and describe a faint movement above the diaphragm. They are due to the right ventricle, which shows itself at this point. Particular conditions are necessary in order that this phenomenon should occur. If the heart presents a vertical form, if it lies on the median line, if the apex is a little lowered and turned in, which results in a slight lifting and a greater salience of the right side of the heart, it is easily

conceivable that the position of the right ventricle may show above the diaphragm. But this is exceptional in the normal state. It is observable, on the contrary, in the course of several pathological conditions and in the following chapter its interpretation will be made clear.

The line GG′ demarcates the whole length of the border of the left ventricle. It follows a convex course outward in its upper third, and then turns round the apex at the level of the left diaphragm.

The point G, from which the line GG′ starts, is particularly interesting to plot exactly, for it corresponds to the position of the left ventricle at the base of the heart. In fact, it is below the contour of the vessels, at the intersection of the middle arc and the lower arc. In order to determine it exactly in practice, it is necessary to have recourse to the orthodiagraphic method which permits the study of the different movements of the organ.

Indeed, if the pulsations are observed which animate the whole left side of the mediastinal shadow, it is seen that at each systole some pulsations move outward and others inward. The shadow of the heart undergoes a retraction movement, while the vascular shadow describes at the same time a movement of expansion. Between these two centers of pulsation, a small zone remains motionless; it corresponds to the left auricular appendage, which caps the left auricle, whose contractions are imperceptible. It is at the foot of this neutral zone, where the ventricular pulsations cease, that point G should be marked. This point is usually opposite point D, either at the same height or a little above it, in tracings taken in the recumbent position, or slightly below in tracings made in the vertical position. It is evident that if as a result of a pathological modification of certain cardiac cavities, this point is lowered or raised to an exaggerated degree, we may infer that the position of the ventricle lies higher or lower. The line GG′, consequently, will be diminished or increased in length, and

this evidence will furnish an element in estimating the ventricular volume. It will be seen further how important the determination is of point G in the study of pure mitral insufficiency.

In the normal state the relation of the lengths of the lines GG′ and DD′ may be written in the following way: GG′ > DD′, and that means that the contour of the left side is more developed than its congener. The excess in favor of the first is from one to three centimeters.

Finally, it is to be noted that point G′ is situated lower than point D′. This is because the heart, resting on the diaphragm from the back forward and from right to left, slightly depresses with its apex the muscle on which it rests and which offers only a feeble resistance on account of the mobility of the organs that lie under it.

The Apex of the Heart. The apex of the heart corresponds to the vicinity of the left diaphragmatic shadow, sometimes a little above, sometimes a little below, when the subject is in a state of apnœa or superficial respiration. During the movements of deep inspiration the apex is detached from the diaphragmatic shadow as well as the inferior contour of the heart (Fig. 5). This latter is then separated from the abdominal shadow by a clear band more or less broad. The transparency of this region is due to the thinness of the pericardial folds, which are inserted in the center of the diaphragm, and this brings out the clearness of the pulmonary tissues situated behind.

The apex and the inferior contour of the heart are sometimes outlined even when the diaphragm is not misplaced downward very much. When the gas bubble in the stomach is large enough, the cardiac shadow is sharply outlined in this clear gaseous zone.

Measurements of the Shadow. When the contours of the heart have been traced by the orthodiagraphic method or fixed on a teleradiographic plate, the evaluation of the surface thus obtained gives the real measure of the organ

according to its plane of projection; this can be expressed in two ways:

(a) by the measure of the area of projection, or

(b) by the length of its principal diameters.

(a) *Measurement of the area.* Measurement of the heart area is made either by means of the Amsler planimeter, or by means of a sheet of paper ruled in millimeters on which one traces the figure and counts the number of square millimeters to which it corresponds.

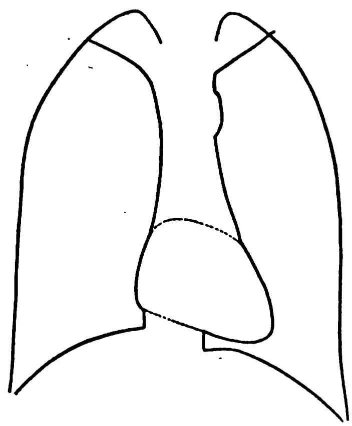

FIG. 5. IN DEEP INSPIRATION THE APEX AND THE INFERIOR CONTOUR OF THE HEART SEPARATE FROM THE DIAPHRAGMATIC SHADOW

However, the figure on which one works contains arbitrary elements. It is only in the pathological condition when the shadow of the heart is very dense that one is in a position to mark on the tracing the lines DG, corresponding to the base, and D′G′, corresponding to the inferior contour. In the normal condition this is not the case, and the construction lines are simply interpretative. And so the calculation of the area can be only approximate.

Moritz, however, has judged it exact enough to serve

as a basis for a number of estimates relative to the size of the cardiac area compared with the stature of the subject.[1]

These are the results at which he arrived:

Stature:

153 to 157 cm., area of the heart varies from 80^{cm2} to 100^{cm2}, average 98^{cm2}.

161 to 169 cm., area of the heart varies from 87^{cm2} to 108^{cm2}, average 102^{cm2}.

171 to 178 cm., area of the heart varies from 92^{cm2} to 126^{cm2}, average 109^{cm2}.

Bouchard and Balthazard,[2] examining 13 men and 36 women, found that the average of the surface of the heart in men was 89.5^{cm2}, with variations from 78^{cm2} to 104^{cm2}; in women 76 square centimeters, with variations from 60 to 96 square centimeters.

Guilleminot and Chiron[3] obtained an average of 79^{cm2} in young people (medical students) from 25 to 30 years old, with variations from 69^{cm2} to 98^{cm2}.

Claytor and Merrill,[4] in studying the cardiac area comparatively with height and weight, have shown that there is no regular relation between the first two values. On the contrary there is a very clear relation between the cardiac area and the weight. These authors show in the study of 37 men that for an increase in weight of 60 per cent the cardiac area increased 39 per cent; this progression began to decline when the weight was more than 65 kilos; in women it is only 25 per cent for 60 per cent increase in weight. These findings are, moreover, in accord with those previously made by Dietlen and Groedel.

(b) *Measurement of diameters.* Moritz traces on the cardiac shadow the four following diameters.

[1] Moritz, Münch. Med. Woch., 1912.
[2] Bouchard et Balthazard, 1900.
[3] Chiron, thèse de Paris, 1905.
[4] Claytor and Merrill, *The Amer. Jour. of the Med. Sciences*, Oct., 1909.

The *longitudinal diameter* (*Langsdurchmesser*) *e f* (Fig. 6), extending from the base of the heart to the apex.

The *transverse diameter* (*Querdurchmesser*) *g h*, perpendicular to the preceding and following approximately the right auriculo-ventricular groove.

The two other diameters, *distance from the middle to the right* (*median-abstand rechts*) *a b, and distance from the middle to the left* (*median-abstand links*) *c d*, are established in the following manner: After having traced a vertical line passing through the middle of the sternum on the heart shadow a point of this line is joined horizontally to the most salient point of the right auricle contour. In this manner *a b* is determined whose length indicates the development of the right side of the heart. By uniting a point of the median line with the most salient opposite point of the left ventricular contour, the diameter *c d* is obtained, which indicates the development of the left side of the heart.

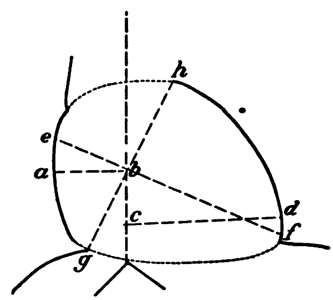

FIG. 6. DIAMETERS OF THE HEART ACCORDING TO MORITZ

e f, longitudinal diameter; *g h*, transverse diameter; *a b*, diameter from the middle to the right; *c d*, diameter from the middle to the left.

The measure of these four diameters has enabled the author to draw up the following table according to the height of the patients:

MEN OF 17 TO 56 YEARS

ORTHODIAGRAPHIC PROJECTION IN HORIZONTAL RECUMBENCY

Height in cm.		*Diameter from middle to right in cm.*	*Diameter from middle to left in cm.*	*Longitudinal diameter in cm.*	*Transverse diameter in cm.*
153–157	Average	4.4	7.9	13.0	10.2
	Maximum	4.8	8.0	13.5	10.5
	Minimum	4.0	7.8	11.5	10.0
161–169	Average	4.4	8.3	13.4	10.5
	Maximum	5.0	9.3	14.5	10.8
	Minimum	3.5	7.5	12.8	9.0
171–178	Average	4.6	9.8	14.0	10.3
	Maximum	5.9	15.3	15.3	11.3
	Minimum	3.0	12.5	12.5	9.0

Claytor and Merrill have proceeded otherwise. They estimated that to measure two diameters was sufficient; a longitudinal diameter starting from the base of the heart, at the intersection of the cardiac curve and of the

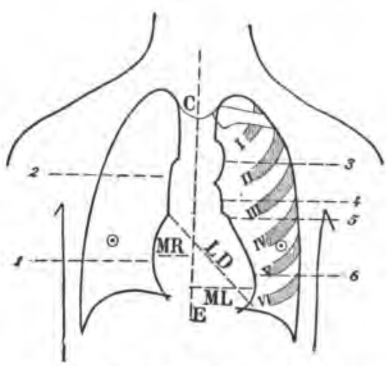

FIG. 7. DIAMETERS OF THE HEART ACCORDING TO CLAYTOR AND MERRILL

LD, diameter longitudinal; MR + ML = transverse diameter.

origin of the blood-vessels, and extending to the apex, and a transverse diameter which represents the total of the two half-diameters (middle to left and middle to right according to Moritz—see Fig. 7). Finally they took as the basis of comparison not the height but the weight of the patients:

CLAYTOR AND MERRILL

TABLE I. ORTHODIAGRAMS OF MEN IN VERTICAL POSITION

Weight in pounds		*Transverse diameter in cm. MR + ML*	*Longitudinal diameter in cm.*
109–117	Minimum Average Maximum	10.7 10.9 11.3	11.8 12.6 13.5
118–126	Minimum Average Maximum	11.0 11.8 12.5	12.0 13.2 14.0
127–135	Minimum Average Maximum	11.0 11.9 13.1	12.0 13.4 14.5
136–144	Minimum Average Maximum	11.5 12.3 13.0	12.5 13.5 15.0
145–162	Minimum Average Maximum	12.0 12.4 13.8	14.0 14.6 15.3
163–181	Minimum Average Maximum	11.0 12.9 13.4	14.0 14.7 15.8

CLAYTOR AND MERRILL

TABLE II. ORTHODIAGRAMS OF WOMEN IN VERTICAL POSITION

Weight in pounds		*Transverse diameter in cm.*	*Longitudinal diameter in cm.*
91–99	Minimum	9.9	12.0
	Average	10.2	12.1
	Maximum	10.5	12.3
100–108	Minimum	10.0	11.5
	Average	10.7	11.9
	Maximum	11.1	12.4
109–117	Minimum	10.2	10.5
	Average	11.0	12.2
	Maximum	12.2	13.8
118–126	Minimum	9.6	11.2
	Average	11.2	12.4
	Maximum	12.6	13.3
127–135	Minimum	10.0	12.2
	Average	11.1	12.7
	Maximum	11.8	13.2
136–144	Minimum	10.9	12.3
	Average	11.6	12.9
	Maximum	12.8	14.2
145–159	Minimum	10.6	11.8
	Average	11.7	12.6
	Maximum	12.6	13.2

The process which we have adopted and usually employ differs little from the preceding. We thought it necessary to reject the method of Moritz, because it seemed to us to be based on an erroneous conception. Moritz established the measurement of the heart by considering it as a perfect ovoid, the figure thus obtained believed to be geometric. This is not true to fact. We thought it more logical to adhere to the method of tracing

only diameters that terminate in real salients in the contour of the heart. It is sufficient to know two diameters only in order to have an exact idea of the volume of the organ.

Now, these two diameters to be determined are the longitudinal and the transverse or horizontal.

The diameter of the height or the longitudinal diameter begins from the intersection of the right contour of the heart and of the origin of the blood-vessels and ends at the apex (line DG of Fig. 8).

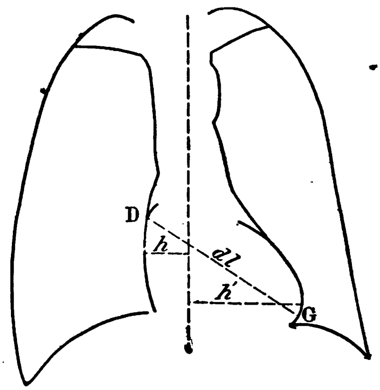

FIG. 8. DIAMETERS OF THE HEART (VAQUEZ AND BORDET)

d l, longitudinal diameter; $h + h'$, horizontal diameter.

The transverse or horizontal diameter is determined a little differently. It ought to represent the greatest distance which separates the right border from the left border, but it is exceptional that the greatest development of each of the two sides of the heart should correspond to a horizontal line; most often it is a more or less oblique line uniting the two extreme points. Now it is interesting to have the horizontal direction of this line preserved. We arrive at this by bringing two lines starting from the right and from the left side of the heart to the point where each of them is most distant from the

sternum and ending on the medio-sternal line. By adding these two half-diameters, we have the horizontal line we seek.

In the recumbent position, as we have said, the two diameters, longitudinal and horizontal, are perceptibly equal. Sometimes, however, the first is greater than the second by from 5 mm. to about 1 cm.; in exceptional cases it is less by several millimeters. In the standing position, the longitudinal position may be increased a little, which is, however, very rare; on the contrary, the horizontal diameter always diminishes. It then becomes inferior to the other by from 5 mm. to 1 cm.

The results which we have obtained in the course of many measurements are fairly comparable to those of Claytor and Merrill. Like these authors, we have seen that the variations in the volume of the heart were proportionate to the weight rather than to the height of the patient. But it should be understood that the weight here expresses the physical and muscular development and not excess of fatty tissue. It is interesting to note that this is the conclusion reached by Polain and Vaquez, from measurements taken after percussing the heart area in young patients.

A third diameter of secondary value (Fig. 8a) is obtained by joining the base of the left ventricle (or point G) with the right cardio-diaphragmatic angle (or point D′). This is designated as diameter D′G. Its length indicates the distance which separates the point of origin of the right ventricular outline from the point of origin of the left ventricular outline, in other words, by development in size of the base of the ventricles. Van Zwaluwenburg and Warren[5] and Otten[6] have drawn attention to the practical interest of this diameter. It is shown on the

[5] Van Zwaluwenburg and Warren, Archives of internal medicine, fol. 1911.

[6] Otten, *Die Bedeutung des Orthodiagraphies für die Erkennung der beginnenden Herzweiterung,* Deuts. Arch. f. Kl. Medi., Febr., 1912.

figure, either by connecting D′ and G by a straight line or by dropping from D′ and G two perpendicular lines to the longitudinal diameter. In the latter case, the sum of the two half-diameters thus traced gives the diameter D′G. The evaluation of this measurement is sometimes useful in translating into figures the hypertrophy of the ventricles at their base. It is evident that if, for example, the walls of the left ventricle increase in thickness, the point G′ will be pushed to the left, and consequently the line DG′ will be increased in proportion. The same fact arises if, on the contrary, it is the point D′ which is thrown toward the right as a result of dilatation or of hypertrophy of the right ventricle. In a series of examinations of the same patient, this diameter may be the only one to vary, while the other two are but little modified, which gives added means of studying the changes in the volume of the heart (see below the figures in Chapter V).

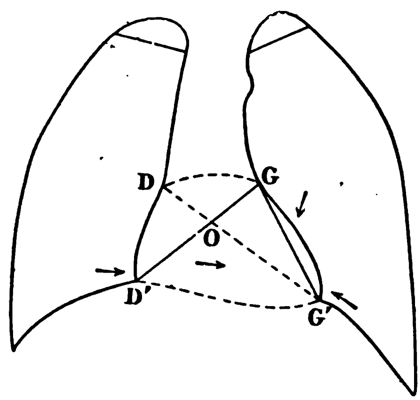

FIG. 8a. DIAMETERS OF THE HEART.*

DG′, longitudinal diameter;
D′G, third diameter;
O, point of intersection.

* This figure was omitted from the French text which the translators used, a text printed in the stress of war. It appeared among the plates received from France after the English version was in type. Hence the irregularity in the numbering.—*Tr.*

The point of intersection of the diameter D′G and of the longitudinal diameter (or point O), the position of which varies according to the degree of inclination of these two diameters, has led Van Zwaluwenburg and Warren to study the relation of the two distances DO and OG′. This relation is approximately proportionate to the relation of the auricular area to the ventricular area. The ratio DO : OG′ would represent the relation of the areas of the auricles and the ventricles. The figure obtained, or index, would vary in normal subjects between 0.534 and 0.704. It would increase when the area of the auricles increases and it would diminish when the area of the ventricles predominates. These authors have found, indeed, in mitral stenosis the index 1000, and in a case of interstitial nephritis the index 280.

Mobility of the heart. To test the mobility of the heart, the patient, placed behind the radioscopic screen, is made to bend the body from right to left of the vertical axis.

When the inclination is toward the left, the heart de-

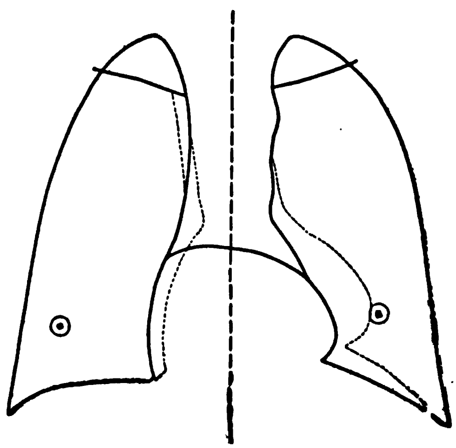

FIG. 9. LATERAL INCLINATION OF THE BODY TO THE LEFT

The black lines are the outlines of the heart in the vertical position (drawn on the skin). The dotted lines are the outline in left lateral inclination.

viates from the median line by about one to two centimeters, which is easy to determine if one is careful to mark on the skin of the patient the two successive tracings of the contour of the apex in these different positions (Fig. 9).

The position of the heart varies equally when the patient passes from the vertical position to the horizontal recumbent (Fig. 10). In the vertical position the heart

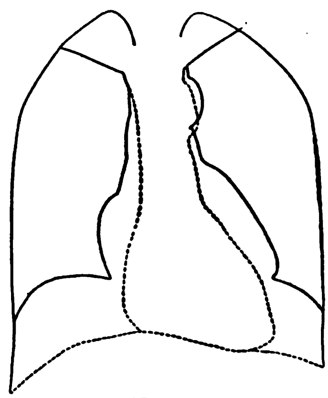

FIG. 10.

Black lines, projection in recumbent position. Dotted lines, standing position.

pulls on the insertions of the base and on the blood-vessels, it rests more on the diaphragmatic dome, and in consequence is lowered as a whole. In the recumbent position, the heart seems to spread, compressed as it is above and behind.

Displacements due to respiration. During deep inspiration the heart follows the movements of the diaphragm and is lowered. At the same time, the organ changes a little in form and its diameters vary slightly; the longitudinal diameter increases and the horizontal diameter diminishes; the result is an elongation and a narrowing of the shadow of the heart.

During deep expiration, the contrary is observed. Under the pressure of the diaphragm, the heart is raised and spreads; both diameters increase, the horizontal more than the longitudinal.

Here, for example, are the figures noted in the case of a normal subject thirty years old.

	Average respiration	*Forced inspiration*	*Forced expiration*
Longitudinal diam. in cm.	11.5	11.8	13.5
Horizontal diam. in cm.	11.5	11.2	15.1

The preceding considerations bear only on forced movements of inspiration and expiration. If the respiration is quiet, the volume of the heart, as Groedel[7] has remarked, does not change notably.

Not less important are the modifications which the respiration causes in the relations of the heart with the diaphragm:

(a) In recumbency, *forced inspiration* lowers the heart and the diaphragm much below their average position (or as in quiet inspiration). The descending movement of the diaphragm extends to a distance of 3 to 5 centimeters.

During *forced expiration,* the heart and the diaphragm are raised only very little above their average position in quiet expiration. (See Fig. 11.)

(b) In the vertical position it is, on the contrary, *forced expiration* which causes the most considerable movement of the heart and of the diaphragmatic contour, but in this case it is the height, whereas *forced inspiration* lowers to only a moderate degree the heart and the diaphragm below their average position (Fig. 12).

[7] F. M. Groedel, *Études radio-cinématographiques relatives à l'influence de la respiration normale sur la grandeur et la position du cœur.* (Zeits. f. Klin. Med. Band LXXII, pp. 292, 310.)

When the patient is standing, the heart, suspended in the pericardial sac, tends to weigh upon the diaphragm and drop under the influence of its own weight; forced inspiration adds very little to this movement. It is quite otherwise in recumbency. The heart is then placed higher. But the insertions of the base hold it only lightly, yielding very easily to the tension which the diaphragm makes on it during deep inspiration.

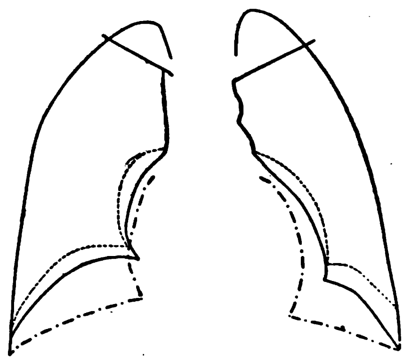

FIG. 11. TRACINGS MADE IN RECUMBENCY

The black lines, quiet respiration. Dotted lines, forced expiration. Dot-and-dash lines, forced inspiration.

Heart pulsation. The radiological study of the pulsation of the heart has not advanced much yet, not because it lacks interest, but because of difficulties of a technical nature. Radioscopy gives only a glimpse of the heart pulsations, but this little is of sufficient value in different cardiopathies to attract attention.

It will be necessary in order to record the constant movement of the different parts of the heart that cinemato-radiography should become a method more constantly used. It alone will be able to record the heart changes, that is, the succession, the amplitude, even the form of the contraction of the different parts of the heart. We shall perhaps be able then to easily recognize aortic

insufficiency by simply observing the ample systolic retraction of the ventricular shadow; cardiac insufficiency by the lagging undulation of the left side of the heart; tachycardiac attack by the sudden explosion of the pulsations; mitral stricture by the intensity of the auricular contraction, etc.

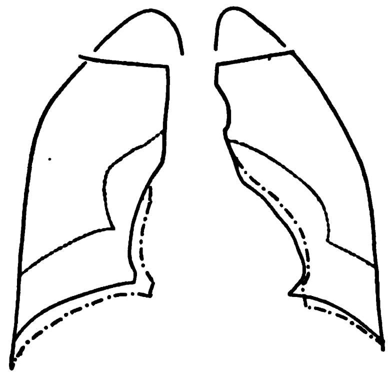

FIG. 12. TRACINGS TAKEN IN THE VERTICAL POSITION

Black lines, quiet respiration. Dotted lines, forced expiration. Dot-and-dash lines, forced inspiration.

A. W. Crane,[8] starting from the work of Gocht and Rosenthal, has succeeded in making radiographic tracings of the heart pulsation. He proceeds in the following manner: he covers the precordial region with a sheet of lead, in which he makes narrow horizontal openings, in such a way that only certain parts of the cardiac outline are projected on the sensitive plate. These openings may be multiplied over the ventricular, auricular, aortic and other contours. A radiographic film is slipped in front of these openings, with the rapidity requisite, during exposure of the thorax to the x-rays from back to front. Tracings are thus obtained comparable to sphygmograms and electro-cardiograms. The strength or the weakness

[8] A. W. Crane, Roentgenology of the Heart. (American Roentgen Ray Society, annual meeting, Sept. 6, 1916.)

of the pulsations of the different heart cavities is interpreted by the variations in the amplitude of the curves. These readings furnish valuable elements in diagnosis.

B. IMAGE OF THE HEART IN OBLIQUE POSITIONS

Right posterior oblique position. In this position the patient rests his right shoulder against the screen with his back to the observer. His left shoulder is, consequently, the farthest from the screen and its distance is maximum when the line which passes through the two shoulders (the bi-scapular axis) forms a right angle with the plane of the screen. As the left shoulder approaches the screen, the angle of obliquity of the body diminishes.

When in the right oblique posterior position the patient is made to pivot round a fixed point which is the right shoulder, in such a way as to make the left shoulder gradually more distant, the angle of obliquity of the body passes successively from 20 to 25, 30, 35 degrees, etc. During this movement, the shadow of the thoracic organs is necessarily modified according to the incidence of the beam of rays. The shadow of the vertebral column which was in the middle of the screen is displaced toward the left, that of the left ventricle, which projected markedly to the left, is transferred toward the right. These two shadows, traveling in opposite directions, finally cross, then the apex of the heart approaches the vertebral column and finally disappears behind its shadow.

In calculating, then, the angle formed by the bi-scapulary axis of the patient with the plane of the screen, we have the angle at which the apex disappears. This notation, made only during orthodiascopic examination, has unquestionable practical value; for the angle at which the apex of the heart disappears in this position is an indication of the development of the organ. To know the degree of it is added evidence in estimating the volume of the heart. In normal subjects this angle is generally

from 25 to 30 degrees (Fig. 13); if it is 40, 45, 50 degrees, it can be concluded that the ventricular cavities are increased in volume.

FIG. 13. ORTHODIAGRAM OF A NORMAL HEART IN THE RIGHT POSTERIOR OBLIQUE POSITION AT 30 DEGREES

The apex of the heart disappears behind the shadow of the vertebral column.

To determine precisely and rapidly the degree of obliquity of the body, Boulitte has constructed an angle indicator or goniometer which is of practical value. This apparatus consists of a horizontal wood rule to which are fastened two perpendicular pieces of wood, the distance between which can be regulated by a series of grooves and which allows them to be fixed at any point. In the posterior position the patient turns his back to the rule and the two perpendicular pieces are placed in the center of the scapular regions. In the anterior position, these two pieces hold the patient, either as we have just explained, or as is preferable in oblique angles of less than 50 degrees, on the anterior surface of the body, at the external third of the clavicle. The bi-scapular axis of the body then remains parallel to the direction of the rule. The rule pivots on one end which is fastened to the frame of the screen, which, for this examination, should have a fixed position. The joint end of the rule has a divided dial. Since the apparatus is fixed to the body all that is necessary for determining the angle of obliq-

uity is to lower the rule by means of a screw and to read the figure indicated on the dial. (See Fig. 14.)

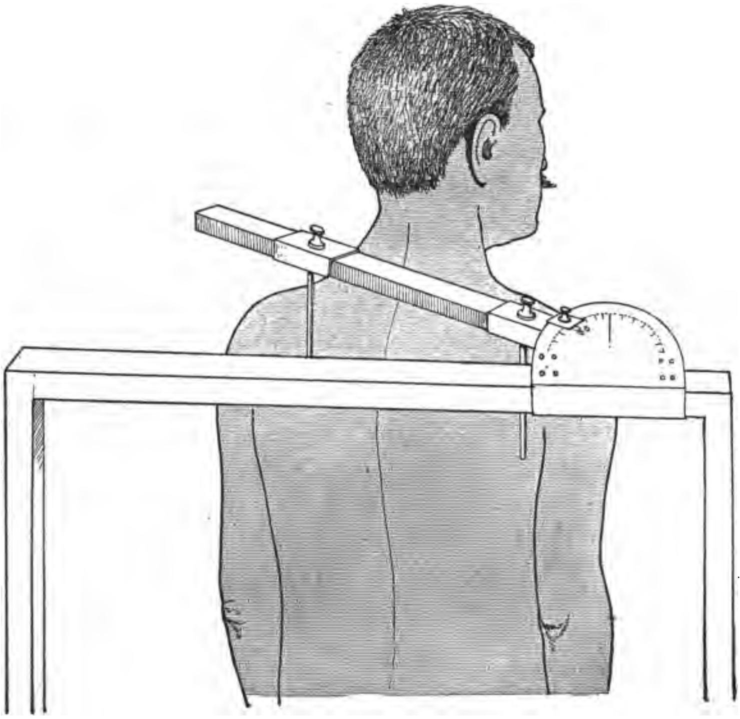

FIG. 14. GONIOMETER OF VAQUEZ AND BORDET

If we continue the movement just described until the patient is in the right posterior oblique position, at an angle of 50 degrees, an image is obtained of the mediastinal organs represented by Fig. 16. In order to understand it, it is necessary in the first place to know to what part of the organ the outline of the shadow corresponds. An examination of the subjoined diagram (Fig. 15) will show it.

It is evident that the normal ray *n n′* enters the left wall of the thorax and comes out at the right wall; tangent to

the heart on the side of the vertebral column, it reaches the left auricle, the walls of which form the most salient part of the heart on a level with the eighth cervical vertebra. By picturing the anatomical aspect in elevation, we deduce that it is the ventricular surface only which ought to develop below the auricle and if the ray passes a little lower it is then the shadow of the left ventricle which is projected on the screen.

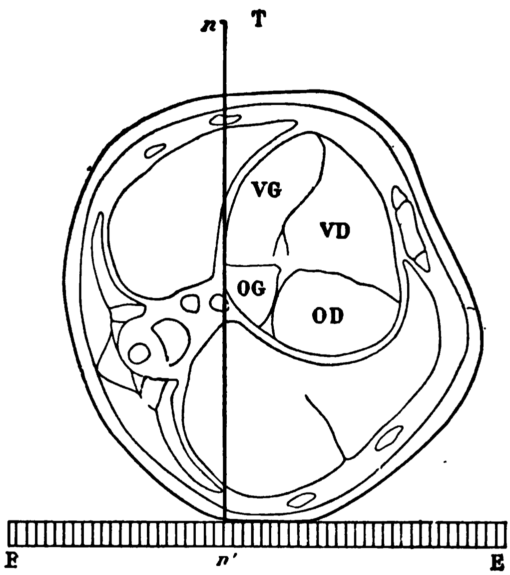

FIG. 15. DIAGRAMMATIC ANATOMICAL CROSS-SECTION (AFTER LUSCHKA). RIGHT POSTERIOR OBLIQUE POSITION

T, Roentgen tube; n n', course of the normal ray; E E, screen; VG, left ventricle; VD, right ventricle; OG, left auricle; OD, right auricle.

By turning to the orthodiagraphic tracing (Fig. 16, from left to right) and studying the details, the following is found:

P G, a clear zone, the left lung; *c*, the shadow of the vertebral column; *e*, the retro-cardiac clear space; OG (below the outline of the aorta), the contour of the left

auricle, above the outline of the left ventricle, VG; VD, the outline of the right ventricle; finally, PD, the clear field of the right lung.

The most interesting part of this figure is the left auricle, OG. This is outlined sharply in the position which is very favorable for the examination of this cavity, which occupies here the postero-superior two-thirds of the cardiac shadow.

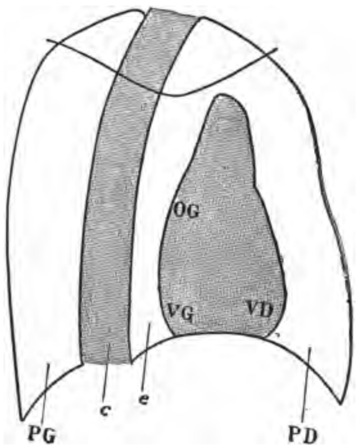

FIG. 16

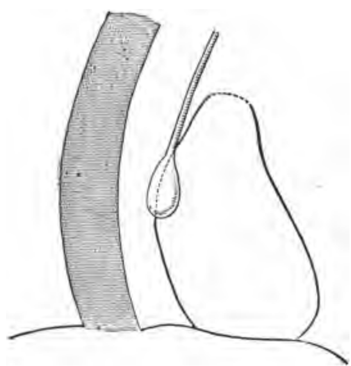

FIG. 17

FIG. 16. ORTHODIAGRAM TAKEN IN RIGHT POSTERIOR OBLIQUE POSITION AT 50 DEGREES

FIG. 17. PROJECTION IN RIGHT POSTERIOR OBLIQUE POSITION OF A SOUND AND OF A TUBE IN THE ŒSOPHAGUS; THE TUBE RESTS ON THE LEVEL WITH THE RIGHT AURICLE

To make sure of it, we objectified the auricle pulsations by means of a tube introduced into the œsophagus and connected with a recording stylus. The tube was filled with bismuth. Now, the patient being in front of the screen, it was seen that the visible pulsations of the auricle were produced just at the moment when the tube was in the region indicated above (Fig. 17).

The distance which separates the outline of the heart from the shadow of the vertebral column diminishes as the angle of obliquity diminishes; very narrow at 40 degrees, it is much larger at 50 degrees. This latter incidence is the most favorable for the study of the heart walls outlined in the retro-cardiac clear space, especially for the study of the left auricle. However, in the case of patients whose thorax is underdeveloped or narrow, the angle of obliquity should be as great as 60 degrees.

When the volume of the left auricle is increased, the salience of its shadow is accentuated and its contour approaches the vertebral column, the reasons for which have just been indicated. Its development is known only if it is known at what angle the patient was placed.

Left posterior oblique position. In this position at an angle of 50 degrees the normal ray penetrates the right antero-lateral thoracic region and comes out at the left

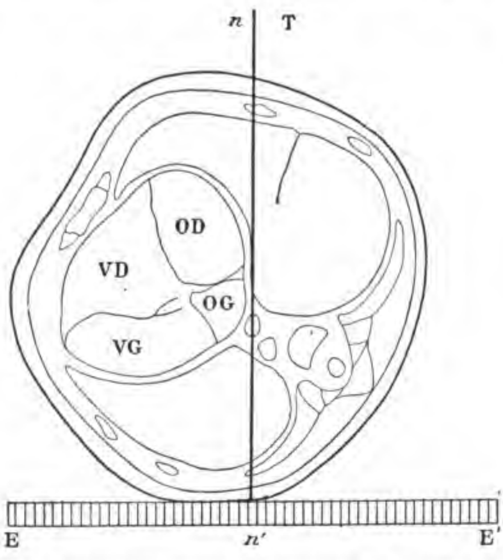

FIG. 18. ANATOMICAL CROSS-SECTION IN LEFT POSTERIOR OBLIQUE POSITION

posterior thoracic region; at the œsophageal zone level, it is tangent to the posterior wall of the two auricles, especially the right auricle. The left auricle and the left ventricle are nearest the observer and the major axis of the heart nearly parallel to the plane of the screen (Fig. 18). The apex of the heart on the left ought then to be seen and a projection obtained extending to the external wall. This is exactly what is shown on the orthodiagram (Fig. 19). On the other hand, in this latter figure, it is seen that the contour of the heart outlines in the clear space the auricles, notably the right, and toward the diaphragm the lower part of the left ventricle. At the right of the figure the tracing outlines the auricles above,

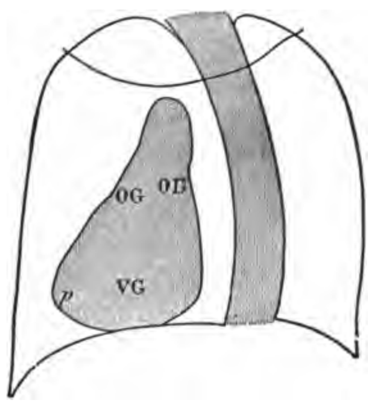

Fig. 19. ORTHODIAGRAM TAKEN IN THE LEFT POSTERIOR OBLIQUE POSITION AT 50 DEGREES

OD, right auricle; OG, left auricle; VG, left ventricle; *p*, apex of the heart.

the left ventricle below; during radioscopic examination, the pulsations of the apex at *p* are clearly seen.

Right anterior oblique position. This position is in a way the inverse of the preceding. The normal ray enters at the left posterior thoracic wall and comes out through

the right antero-lateral thoracic region (Fig. 20); the right auricle and the right ventricle are nearer the observer.

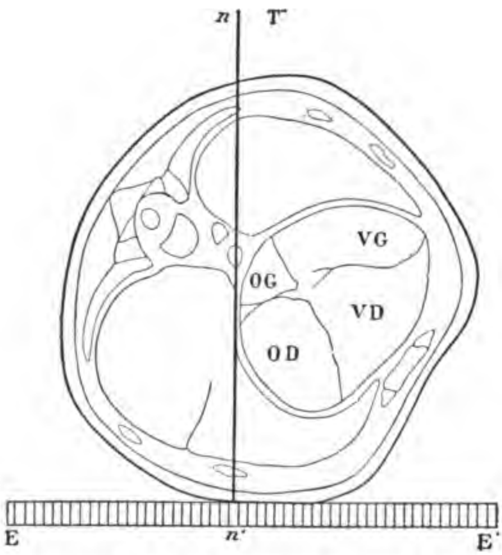

FIG. 20. ANATOMICAL CROSS-SECTION IN THE RIGHT ANTERIOR OBLIQUE POSITION

In Fig. 21, the left contour, the outline of which is seen in the retro-cardiac clear space, does not show, at 50 degrees at least, the right but the left auricle. The posterior wall of this cavity is found to be nearest the dorsal wall of the body. If the bi-scapular axis describes an angle greater than 50 degrees, the left auricle shows more; if, on the contrary, the angle is less than 50 degrees, it is the contour of the right auricle which appears.

Below the auricular shadow, in the clear space, the right ventricle is outlined.

At the right of the figure the contour of the organ outlines the right auricle above; below and all along the diaphragm, the right ventricle.

Left anterior oblique position. The normal ray enters

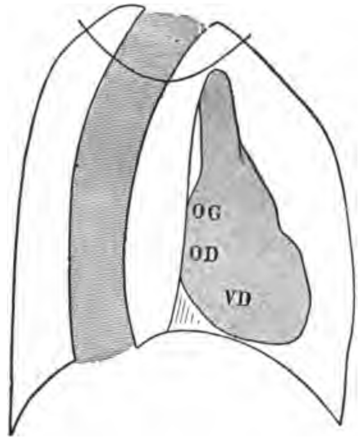

FIG. 21. ORTHODIAGRAM TAKEN IN THE RIGHT ANTERIOR OBLIQUE POSITION AT 50 DEGREES

OG, left auricle; OD, right auricle; VD, right ventricle.

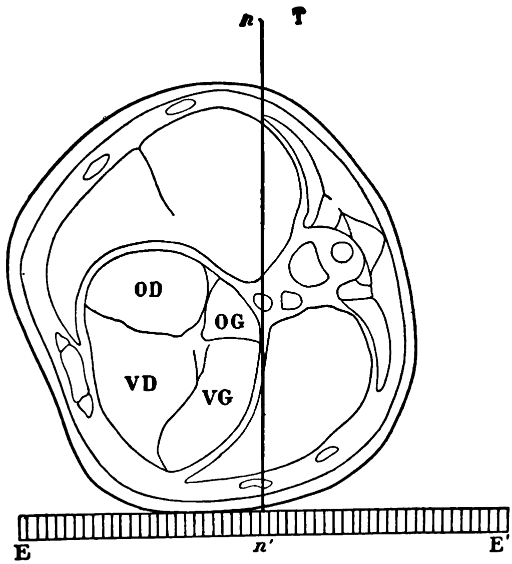

FIG. 22. ANATOMICAL CROSS-SECTION IN LEFT ANTERIOR OBLIQUE POSITION

the right posterior thoracic wall and comes out at the left antero-lateral costal wall (Fig. 22). At 50 degrees the orthodiagraphic tracing is obtained as seen in Fig. 23. The outline of the heart in the clear space shows the left auricle in the upper part and the left ventricle in the lower part. At the level of the diaphragm, the contour curves sharply to the left downward. The apex of the heart lies at *p* and is near the observer. In short, in this position, the major axis of the heart follows, from back to front, the same direction as the normal ray. At the right the line of the contour delimits the right auricle above and the right ventricle below.

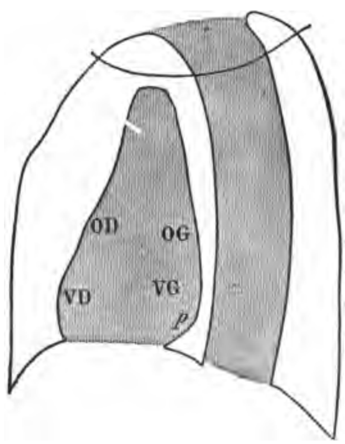

FIG. 23. ORTHODIAGRAM TAKEN IN THE LEFT ANTERIOR OBLIQUE POSITION AT 50 DEGREES

OD, right auricle; OG, left auricle; VD, left ventricle; *p*, apex of the heart.

Lateral positions. The lateral positions, right and left, are obtained by placing the patient in such a way that with either the right shoulder or the left shoulder in contact with the screen, the bi-scapular axis forms an angle of 90 degrees.

The cardiac shadow is separated behind from the verte-

bral column by a narrow, clear band; this is the retro-cardiac clear space. In front it is separated from the sternal outline by another clear band (Figs. 24 and 25) which is the retro-sternal clear space.

This space may be much reduced or completely disappear at the lower part when the heart is enlarged in volume or when adhesions fix the mediastinum to the sternum. In the right lateral position there is a good view of the proximal and terminal portions of the arch; in the left lateral, the superimposed dilatations of the pulmonary and aortic arches are seen.

In these positions it is convenient to observe the outline of the thorax. If during inspiration and during expiration the sterno-abdominal contours are successively drawn, two lines are obtained perceptibly parallel for most of their length. They meet only at the level of the umbilical region (Fig 26). Wenckebach has shown that in the case of extensive pericardial adhesions, the amplitude and form of these respiratory outlines are more or less modified. Later reference will be made to this question of cardiac symphysis.

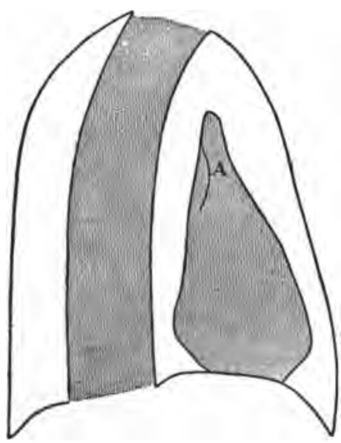

FIG. 24. RIGHT LATERAL POSITION

A, ascending aorta.

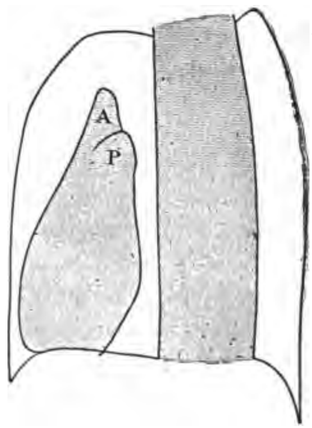

FIG. 25. LEFT LATERAL POSITION

A, aorta; P, pulmonary area.

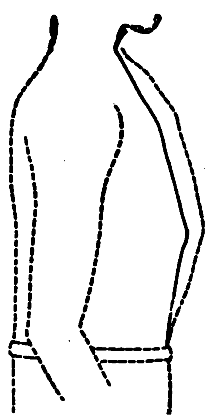

FIG. 26. RESPIRATORY OUTLINE (ORTHODIAGRAPHIC) OF A NORMAL SUBJECT

Black line, forced expiration; dotted line, deep inspiration.

III. VARIATIONS OF THE PHYSIOLOGICAL FORM OF THE HEART

In the preceding description we have taken as a type the form of the heart most common among normal adults of average weight and height. It corresponds to what investigators call the *oblique* type. But, even in the physiological state, the form of the heart can vary a little. Two other variations have also been described, the horizontal and the vertical. The horizontal heart rests more on the diaphragm than the oblique. The vertical heart is narrower and more elongated (Fig. 27).

These particular variations of the heart result in slight modifications in diameter, which when interpreting the tracings must be taken into account.

Most often it is necessary to ascribe these different forms of the heart to a special conformation of the thorax. The horizontal type of heart is met with especially in subjects of small stature and short thorax, and the vertical type in individuals whose thorax is narrow and long.

The vertical or small heart has been wrongly considered a pathological variation and thought to be a sign of pulmonary tuberculosis. It is frequently found in this

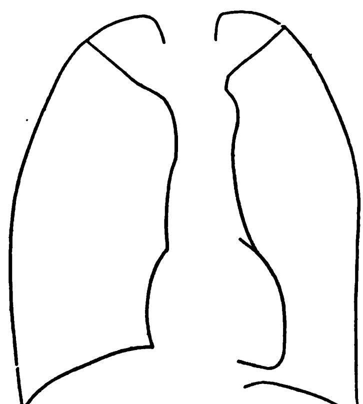

FIG. 27. VERTICAL HEART

disease, but that is not due to tuberculosis, but to the fact that the tuberculous usually have a narrow elongated thorax. The same form of heart can be found among patients free from tuberculosis, whose thorax has caused the same condition.

There should be mentioned among the physiological forms of heart displacement, that form which has been given the name of dropping heart (*Tropfherz, cor pendulum, cuore a goccia, cœur suspendu*). It is well understood that this displacement is quite different from that of cardioptosis, which constitutes a pathological variation. *Cor pendulum* differs from it in that the heart is not lowered as a whole, but is simply held in suspension by its attachments to the vessels of the base and to the ligaments of the neck, the heart apex resting a slight distance from the diaphragm, which drops below it, leaving a clear and sometimes rather broad band between the heart and diaphragm.

According to Wenckebach, this abnormal configuration results from the lowering of the insertion of the diaphragm coincident with an elongation of the thorax; he thinks, moreover, that it is accompanied by rhythmic lowering movements of the larynx, resulting from the pull which the heart exerts on the muscles of the larynx during systole. This idea, if it is correct, would take away much of the value of the rhythmic lowering of the larynx, or Oliver's sign, which is generally considered a sign of aortic aneurism.

Two other peculiarities may be mentioned, which might wrongly be considered of a pathological nature, but which are, however, compatible with the normal.

The first consists of a shadow on the diaphragm, at the level of the attachments of the pericardium, which increases during deep inspiration and then takes on the aspect of a triangle, the base of which rests on the diaphragm itself (Fig. 28).

This image appears at first different from that which

is usually found. It is admitted that the fibrous pericardial sac, which is inserted over the dome of the diaphragm and adheres closely to the phrenic center, gives only an inappreciable shadow above the left portion of the diaphragm. Besides, this shadow disappears entirely in forced inspiration, the heart being then separated from the diaphragm by a clear space which corresponds to the base of the left lung and the lower edge of which is outlined for the greater part of its length against the clearness of the pulmonary tissue.

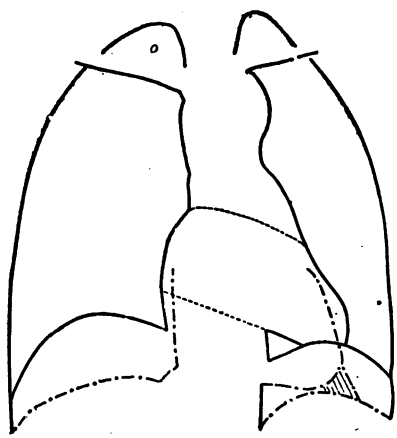

FIG. 28. INSERTION OF THE PERICARDIUM VISIBLE DURING DEEP INSPIRATION ON THE LEVEL OF THE CARDIO-DIAPHRAGMATIC SINUS

However, it is not uncommon that instead of this position the image represented in Fig. 28 is obtained, in physiological hearts, and in patients indiscriminately fat or thin. It is due, very likely, to a certain thickening of the pericardial folds. Images produced by the presence of shadows due to pathological adhesions can be distinguished by the fact that one may there recognize the inferior contour of the heart apex, always darker than the shadow of the pericardial-diaphragmatic tissues, and

this is ordinarily impossible when adhesions exist; on the other hand, the movements of the heart keep their normal amplitude during respiratory displacements and the expansion of the diaphragm.

The other condition that might equally well lead to a false conclusion as to the presence of adhesions of the pericardium is found in certain obese patients, whose left cardio-diaphragmatic sinus, instead of being clear, is filled by a shadow, less heavy, it is true, than that usually cast by the heart. This shadow may be due exclusively to the existence of a fatty cushion surrounding the apex of the heart. Schwartz[9] has proved this by his studies on cadavers.

IV. PARTICULAR STUDIES TO DETERMINE VENTRICULAR DEVELOPMENT IN DEPTH

The observation of the heart in the right posterior oblique position allows the determination at what angle the apex disappears behind the shadow of the vertebral column. This angle determines the function of the left cardiac border outline. The goniometer shows that it is small, 25 degrees for example, in the case of a vertical heart, and a little greater, about 30 degrees, in the case of a horizontal heart.

Our procedure has been subjected to some modification by several investigators. Josué, Delherm and Laquerrière[10] have used, instead of the goniometer, a revolving platform on which the patient is placed, and which gives the degree of obliquity of the body. Beaujard[11] calculates not the angle at which the apex disappears, but another sagitto-spino-ventriculo-tangential, or ventricular volumetric angle which is equal to it.

[9] G. Schwartz, *Sur une caractéristique radioscopique du cœur des obèses et sa raison d'être anatomique.* (Wiener Klin. Woch., 1910, no. 51, p. 1850.)

[10] Josué, Delherm and Laquerrière, *Bulletin de la Société de Radiologie,* 1914.

[11] Beaujard, *Bulletin de la Réunion Médicale de la 7e Région, 15 sept., 1917.*

In a general way these methods confirm the results at which we have arrived; but they necessitate apparatus more or less complicated. We have found more simple another procedure which gives, not the angle at which the apex disappears in the right posterior oblique position, but a practical and rapid estimate, in depth, of the ventricular development. The calculation of the angle of disappearance already gives us this information, for it is an action, not only of the outward push of the apex, but also of ventricular enlargement behind. To this latter factor preponderant importance is attributed. We know that the left ventricle forms very little of the anterior surface of the heart and that its position is, for the most part, deep and mediastinal. The result is, then, that to diagnose incipient ventricular hypertrophy, it is necessary to be able to determine the degree of enlargement of the left ventricle in depth.

Our procedure adopts the radioscopic method in plotting the depth of foreign bodies. It is based for the most part on the relation of like triangles. The principal outlines are these:

In Fig. 29, let O be the projectile to locate; E, the radioscopic screen; A, the tube, which is 60 centimeters from the screen. In position A, the tube gives a normal ray which passes through the foreign body O, the image of which falls at C. This first projection is marked with a crayon on the glass of the screen. The tube is moved from A to A′, a known distance, 10 centimeters. The beam of rays reaching O projects the image at C′. This is marked on the glass, C′. It is easy to calculate by means of a millimetric rule the distance CC′ which separates the two crayon marks. On the other hand, AC and AA′ are known. These three elements allow the graphic construction or the mathematical calculation to be made, which, given the two like triangles AOA′, COC′, gives the value OC, that is to say, the distance of the foreign body from the screen.

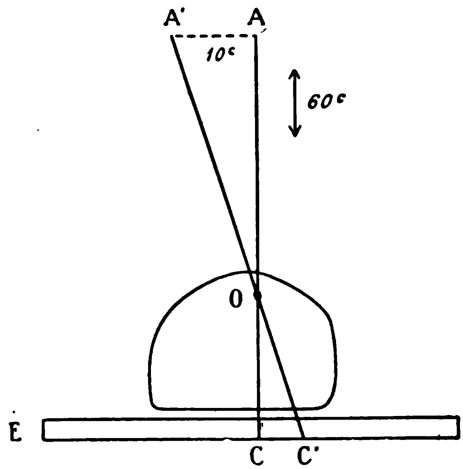

FIG. 29. FIGURE REPRESENTING THE METHOD OF DEVIATING THE TUBE IN ORDER TO LOCALIZE FOREIGN BODIES

E, screen; AA′, two positions of the tube; O, projectile; CC′, projections of the foreign body.

By repeating the same method, having for the object the apex of the heart of a normal subject, and not a foreign body, and by bringing the ray AN tangent to it (Fig. 30, black lines), a projection is obtained of the apex that is not deformed. Mark with a crayon on the screen point N, which coincides with the outer edge of the shadow; then move the tube 10 centimeters toward the left of the operator. The image of the apex is seen to have become deformed and displaced toward the right. Mark a second point (N′) to fix the amplitude of the displacement. A millimetric rule allows of its calculation.

A case of hypertrophy of the left ventricle is presented here as an example (Fig. 30, contours and lines dotted). The enlargement in volume has only a bearing on the mediastinal contour of the left ventricle. The apex is not pushed out, it occupies the same lateral position as in the physiological condition (black lines). The normal ray,

tangent to the apex of the heart, unites in the two cases. But when the tube is moved the oblique ray meets the contour of the left ventricle sooner than in a normal organ, and it projects the outline of it, not at N′, but at G′, much farther from N than from N′. The deviation is considerable. It shows, obviously, an increase in volume of the left ventricle in depth.

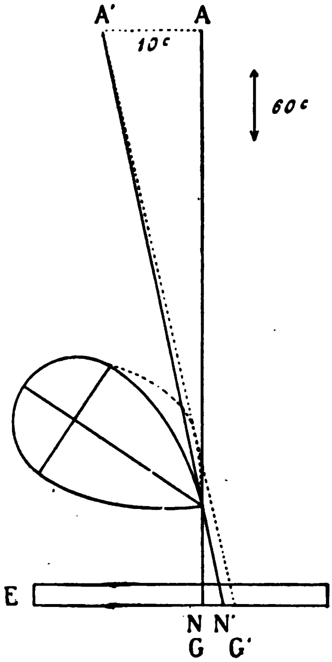

FIG. 30

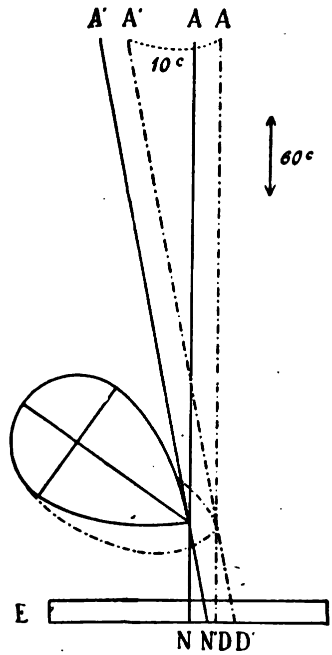

FIG. 31

FIG. 30. DIAGRAM OF THE METHOD FOR FINDING THE INDEX OF DEPTH IN CASE OF HYPERTROPHY OF THE LEFT VENTRICLE

AA′, positions of the tube; NN′, GG′, projections of the normal ray and of the oblique ray.

FIG. 31. SAME METHOD IN CASE OF ENLARGEMENT OF THE RIGHT VENTRICLE

AA′, positions of the tube; NN′, DD′, projections of the normal ray and of the oblique.

It will be noted on the figure that it is not the depth of the apex which this method reveals, but the maximum of salience of the posterior contour of the heart, situated behind the apex and in the path of the oblique ray. Greater depth may be present outside of it. The process then does not give the antero-posterior diameter of the heart, but valuable indications as to a point on the posterior surface of the organ.

When the right ventricle alone is increased in volume, the result of the tube manipulation gives the following (Fig. 31, contours and lines black and dotted):

The normal ray ends at D, the oblique ray at D′. The deviation is a little greater than in the case of a physiological heart, but less considerable than in the case of an hypertrophied left ventricle. The importance of the projecture of the apex does not influence the oblique ray. It is the depth of the apex that determines the deviation DD′; so in the actual casé, its maximum of posterior salience is hardly more accentuated than in a normal case. The principal development of the right ventricle is anterior, and consequently is out of the course of the oblique ray.

In practice this fact can be verified equally well by the calculation of the angle of disappearance of the apex in the right posterior oblique. Beaujard and Caillods have pointed it out. In order that the index of depth be raised, in cases of increase in volume of the right ventricle, it is necessary that the right ventricle press the left ventricle down or that the latter increase concurrently in volume.

Definite information on the enlargement of the right ventricle should not be expected from this procedure. The ordinary signs of the enlargement of this cavity are sufficient. On the other hand, the method of moving the tube on the scale becomes extremely important when it is a question of determining in depth the development of the left heart. When there exists no other radioscopic

indication, incipient hypertrophy of the posterior wall of the left ventricle may be recognized by it.

The technic is simple: the patient is placed behind the fixed screen, 60 centimeters away from the anticathode. The patient may be in the prone or upright position. The vertical position is preferred, as the body is made immovable by the contact of the anterior surface of the thorax with the screen.

The method is essentially this: (1) center the tube on the apical region and indicate on the glass with crayon the extreme outline; (2) place on the screen a rule furnished with two points 10 centimeters apart. The scale on the right coincides with the first crayon mark and with the cardiac outline; (3) move the tube to the left of the observer until the normal ray passes through the second point on the rule; (4) open the diaphragm wide, raise the rule and mark a crayon point opposite the first, on the new outline of the apical area; (5) count the number of millimeters that separate the two crayon marks.

The figure thus obtained *shows the development of the heart in depth.*

All the points of the cardiac outline left and right can be investigated in the same way. In normal subjects the figure varies at the apex from 7 to 14 millimeters. It is generally about 10. It has the same value—sometimes 1 or 2 millimeters more—on the left side toward the base. At the apex and at the base it may be raised to 18, 20, 25, and 30 millimeters in the course of different cardiac affections.

V. SUMMARY AND CONCLUSIONS:

RULES TO FOLLOW IN RADIOLOGICAL EXAMINATION OF THE HEART

The details of the radiological examination of the heart being known, the technic is as follows:

1. The first step is the *radioscopic examination of the*

heart as a whole. This examination, under the fluoroscope, will give a general view of the heart, its form as well as its relations to the thoracic cavity contents: lungs, pleuræ, pericardium and posterior mediastinum. The patient will be in the vertical position and will in turn present front, back and oblique positions to the screen; the latter positions will show the degree of transparency of the retro-cardiac space.

2. The next step is to *take a radiogram.* According to the apparatus at one's disposal, this will be an orthodiagram or a long-distance radiogram, or better, both in succession. These are the first steps in studying the heart. Its volume is also determined by fixing the contour of the real projection of the heart shadow.

The patient will be in the frontal position, upright or prone as the case may be, but care should be taken to have him perfectly immovable and held in a plane parallel to that of the screen or of the plate.

On the radiogram thus obtained the diameters of the heart can be established, and an examination made of the development of the right and left contours, their relations, the position of the apex, its form and its distance from the left contour of the thoracic cavity.

3. The next step is to determine some *points of detail.* For this the orthodiagraphic method is applied, which alone can give special information concerning:

(a) The position of point G.

(b) The index of the development of the heart and particularly of the left ventricle in depth.

(c) The amplitude of the respiratory displacements of the heart and the diaphragm.

(d) The degree of mobility of the apex of the heart.

(e) The development of the inferior contour of the heart observed during deep inspiration.

(f) The nature of the pulsations which animate the contours of the heart.

4. The final step is the *examination of the heart in*

oblique positions. The patient is placed successively in all the oblique positions described, so that a more precise analysis may be made of the various modifications of form already studied, and especially, that the angle of disappearance of the apex in the right posterior oblique position may be determined. In this way the respective increases in volume of the different cardiac cavities can be measured, the size of the retro-cardiac clear space and the outline of the heart shadow at its level. Though this latter examination need not be conducted in as regular a manner as the others, and though it can be made equally well by radioscopy or by intensive radiography, nevertheless it is indispensable to know the angle of obliquity at which the patient was placed during the examination. It is unnecessary to point out that the modifications of this or that part of the heart at a given angle may lead to interpretations which differ but are always helpful in diagnosis.

CHAPTER III

THE SHADOW OF THE HEART IN THE PATHOLOGICAL STATE

THE pathological changes in the volume of the heart are complete or partial: *complete,* when they affect the organ as a whole; *partial,* when they concern only certain cardiac cavities.

The shadow cast by the organ determines certain modifications which will be studied with the assistance of certain clinical facts, in order to give examples instead of diagrams.

MODIFICATIONS AFFECTING THE WHOLE HEART

These are shown by an increase or diminution in the surface of the shadow.

The estimate of the shadow as a whole is made by measuring its area (by means of Amsler's planimeter or millimetric ruled paper) and the diameters of the projection. This double measurement is necessary because the diameters may change in the same patient, according to the different phases of the disease, without any variation in the total surface.

Sufficiently precise data are had from a first examination to judge whether the heart shadow of a patient is increased or diminished in volume. Moritz, Dietlen, Groedel, Claytor and Merrill have drawn up tables of normal areas and diameters according to age, height, weight and sex; these will be merely referred to, care being taken to compare the figures with those of the

tracings taken in the same positions, for the diameters vary according as the patient is examined in the upright or prone position.

According to Dietlen[12] the volume of the heart is increased as soon as a tracing exceeds the normal corresponding tracing by five millimeters for the diameters and five square centimeters for the area; it is diminished when the measurements are less than those which correspond to the smallest normal tracings taken in the same conditions of position, age, weight, and sex.

These deductions, however, should not be accepted without reservation, and if the orthodiagraphic method is sufficiently accurate clinically, it is far from having, even in experienced hands, a geometric precision. Almost always, moreover, modifications affecting the whole heart are transitory and it is rather from the comparison of several serial tracings taken at different intervals in the same patient that conclusions can be drawn, and, in general, it is sufficient to superimpose the tracings in order to read the changes in volume. The list of successive measurements of areas and diameters explains equally well the anatomical pathological variations in the heart volume.

Increases in the heart as a whole are met with especially in the course of infectious diseases: diphtheria, pneumonia, typhoid fever (Dietlen). They are particularly important in cases of myocarditis. Fig. 32 shows the successive contours of the shadow of the heart in a man of forty-four with very severe alcoholic myocarditis, benefited by intravenous injections of strophanthin.[13] The line in dots and dashes gives the image of the heart before treatment; the dotted line, the result after the first injection; the black line shows the cardiac shadow when

[12] Dietlen, Münch. Med. Woch., 6 October, 1908.

[13] Vaquez et Leconte, Les injections intra-veineuses de strophantine dans le traitement de l'insuffisance cardiaque. (Soc. méd. des hôpitaux, 26 mars, 1909.)

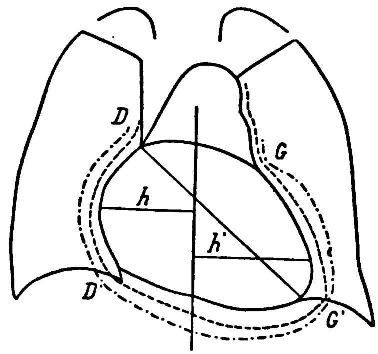

FIG. 32. ALCOHOLIC MYOCARDITIS

By comparing the three superimposed tracings marked by different lines, one can follow the progressive decrease in the volume of the heart under treatment. The tracing in black lines was taken the day the patient left the hospital.

finally, three months later, the patient left the hospital cured.

The diameters and areas were:

	Area	*Longitudinal Diameter in cm.*	*Horizontal Diameter in cm.*
October 29, 1908......	168cm²	17.7 cm.	18. cm.
November 4, 1908.....	159cm²	17.7 cm.	17.5 cm.
January 28, 1909.....	132cm²	15.8 cm.	15.3 cm.

PARTIAL MODIFICATIONS

The ascertaining of partial modifications in the volume of the heart is more important than determining modifications in the heart as a whole, for valuable information is had as to the reaction of the different cavities of the organ upon its organic lesions.

I. DETERMINATION OF THE TOTAL VENTRICULAR VOLUME

The increase in volume of the two ventricles is shown by the abnormal development of the outline in the left pulmonary field on a cardiogram taken in the frontal position.

In this case the apex is pushed out toward the thoracic wall, which it sometimes touches. Moreover, it is depressed and may, in certain cases, be seen only at two or three and more centimeters below the diaphragm in deep inspiration. Its form becomes rounded or globulous. The longitudinal diameter is elongated, sometimes 18 to 20 centimeters and more, and the horizontal diameter increases, especially in that portion which meets the left border. This border is longer on account of the apex being lowered, the area of origin elevated (point G), and the external convex curve accentuated.

The importance of the ventricular area may be equally well determined by another more rapid method, which consists in finding under what angle of obliquity of the body the heart shadow disappears behind the vertebral column shadow in the right posterior oblique position. In a normal subject it ceases to be visible at an angle of 30 degrees on an average. This examination is made before a fixed screen, keeping the normal ray tangent to the apex and making use of a movable back which indicates the angle of obliquity of the body. The disappearance of the cardiac shadow behind the vertebral column at an angle of obliquity of 40 degrees or more warrants the conclusion that the ventricular area is increased in volume[14] in proportion to the increase in the angle. We have seen it exceed 65 degrees in certain cases of aortic insufficiency.

[14]It is evident that these considerations cease to be exact if, for reasons independent of the variations in the volume proper of the heart, such as pleural adhesions, effusions, etc., the organ is displaced either to the right or to the left of its vertical axis, or depressed in depth.

The tracings in Figs. 33 and 34 are of a man of forty-eight, 1 m. 68 cm. in height, suffering from mitral disease, with easily provoked dyspnœa, pulse small and arhythmic. Examination in frontal position, prone (Fig. 33), shows that the apex is pushed out and lowered (by palpation, pulsation was felt in the sixth intercostal space); the longitudinal diameter measures 17 centimeters (normal average at this height, 13 to 14 centimeters); the horizontal diameter is 15.9 cm. (average, 13 to 14 centimeters), the middle arc is exaggerated and the point G is lowered; finally, in right posterior oblique position (Fig. 34) the ventricular shadow is still visible 50 degrees to the left; it disappears behind the vertebral column only at an angle of 55 degrees.

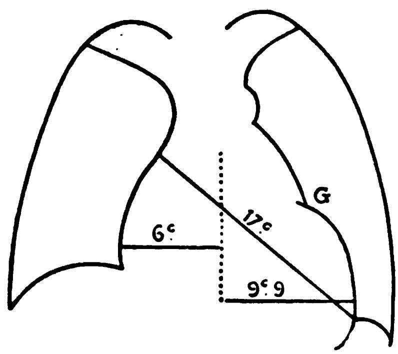

FIG. 33. INSUFFICIENCY AND MITRAL CONTRACTION

The exaggerated development as seen on this tracing is due to the increase in the volume of the two ventricles.

In analogous cases we can estimate the development of the ventricles in depth by using the method with the tube on a sliding scale, as has been described. The index figure in the case of right and left ventricular enlargement, but especially left, rises to 20, 25 millimeters and more. If hypertrophy of the right ventricle is predominant, the index remains nearly normal.

It will be of interest therefore to examine the orthodiagraphic data relative to the modifications in volume of each of the cardiac cavities.

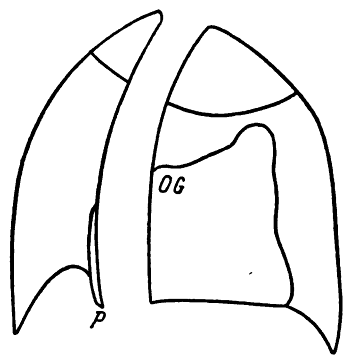

FIG. 34. SAME HEART AS IN FIG. 33, IN RIGHT POSTERIOR OBLIQUE POSITION

At 50 degrees the ventricular area has not yet disappeared behind the vertebral column.

II. LEFT VENTRICLE

Clinically this is a typical case of left ventricular hypertrophy. Fig. 35 is of a patient thirty-three years of age, weighing 67 kilos, height 1 m. 71 cm., suffering from aortic insufficiency with compensation. The first important point in this figure is that the apex of the heart is pushed outward only a little, but it falls below the diaphragm even during deep inspiration. The horizontal diameter measures 12.8 cm. and the longitudinal diameter, 13.5 cm. By referring to Moritz's tables, the longitudinal diameter for a man 1 m. 71 cm. in height would be 12.5 cm. It is increased then by one centimeter. On the other hand, the horizontal diameter remains in this case nearly normal. Point G is raised, the general form of the left contour is modified, its convexity is accentuated, the apex of the heart is rounded.

In the right posterior oblique position the cardiac shadow disappears behind the vertebral column at an angle of 40 degrees. The index in depth exceeds 15 millimeters. The conclusion is plain: the ventricular volume is exaggerated. Oblique examination and examination in depth complete the data of the tracings made in the frontal position, especially in cases in which anatomical changes are not marked. It is understood, moreover, that in the right posterior oblique position the least

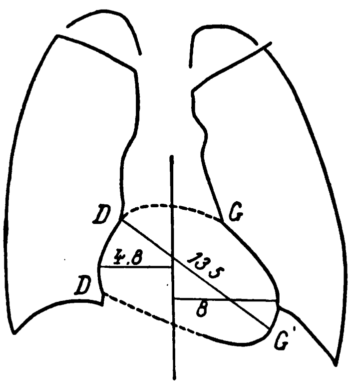

FIG. 35. HYPERTROPHY OF THE LEFT VENTRICLE (AORTIC INSUFFICIENCY)

The apex of the heart is at G′, lowered, rounded, the left ventricular outline GG′ is elongated.

changes in volume of the left ventricle are easily seen. This cavity corresponds especially to the posterior part of the organ; when it increases, it does so not only toward the left, but also in its antero-posterior diameter. As it is the projection of the postero-lateral contour of the left ventricle which is shown on the screen in the right posterior oblique position, it is quite natural that this shadow, when it corresponds to an enlarged cavity, should disappear slowly. It is also understood that in finding the index in depth, the oblique ray encounters the contour

of the heart lower down and projects the shadow of it further toward the left.

When the hypertrophy of the left ventricle is more pronounced, the apex is pushed further out and lower, the contour of the left border is more convex and longer, the heart takes the shape of a pear, as described by Destot and Arcelin;[15] the elongation of the diameters increases, the angle of disappearance of the apex in the right posterior oblique position is larger, as also the index in depth.

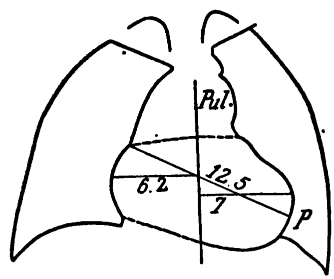

FIG. 36. CONGENITAL PULMONARY STENOSIS

The right ventricle, alone increased in volume, rests on the left diaphragm, which it depresses; the left ventricle is pushed up and outward, the apex is seen at P (heart in the form of a "sabot").

III. RIGHT VENTRICLE

This will be taken as an example of an affection in which the left ventricle ordinarily keeps its normal volume, while the right ventricle is greatly enlarged, as occurs in lesions of the pulmonary artery.

Fig. 36 represents the frontal projection in the prone position of a heart of a child fourteen years of age with congenital pulmonary stenosis accompanied by marked cyanosis and dyspnœa. In a general way a notable arterial saliency is observed due to the dilatation of the pulmonary artery (Pul) and a considerable enlargement

[15] Arcelin, *Les formes de l'aire de projection du cœur pathologique.* Lyon, 1906.

of the right ventricle. In detail the tracing is analyzed as follows:

The longitudinal diameter measures 12.5 cm., which is too much for a child of fourteen; the horizontal diameter is still greater, 13.2 cm. The apex (P) is pushed outward and raised. On this account the position of the left ventricle (G) is higher than normal, but the total length of the ventricular contour keeps its usual dimensions (7.3 cm.). Moreover, its double undulation is not modified.

The shadow thus formed at the apex belongs to the right ventricle, the lower border of which can be followed below the diaphragm. When, as is not unusual, it is difficult to fix the outline by a simple examination on the screen, it can be done more surely by giving the patient two solutions in succession: one of bicarbonate of soda, the other of citric acid, which forming a gas render the stomach transparent. If this contour were that of the left ventricle it would have a more vertical direction and the apex would hang like the bottom of a purse, whereas here the form of the cardiac shadow resembles somewhat that of a "sabot."

The enlargement of the right ventricle is seen on the right by an exaggeration of the outline in its lower third below the auricle. To make sure that it is the ventricle and not the auricle which projects at this level, take the patient's pulse and note that each radial pulsation coincides with the systolic retraction of the shadow in the region examined, whereas the pulsation would be presystolic if it were a question of the auricle.

Further than that, the same outline of the shadow at the right of the sternum can be found in cases in which the ventricle, not increased in volume, is only pressed toward the right by the hypertrophied left ventricle. But this compression is not accompanied by signs which show the enlargement of the right ventricle, the lengthening of the diameters, especially the horizontal, the push-

ing outward and elevation of the apex and the lowering of the inferior contour of the heart.

In *left anterior oblique position* an outline is obtained which confirms the preceding data. By referring to Fig. 37, the line of contour of the heart, situated at the left of the image, limits the right auricle above, then the right ventricle as far as the diaphrågm. The shadow is seen to be very markedly increased, which corresponds to the enlargement in volume of the right ventricle. The dotted line indicates schematically the normal contour in this position. Finally, in the right posterior oblique position the angle of disappearance of the apex cannot be exaggerated. It has been seen that the projection of the apex toward the left is not enough in itself to increase this angle and that it is necessary that the development of the area in depth be increased in order that this take place. The determining of the index leads to the same results, on the left, at least. In cases where the right ventricle projects toward the right and pushes the auricle up, the index in depth may be exaggerated on the right, while it is normal or nearly so at the apex.

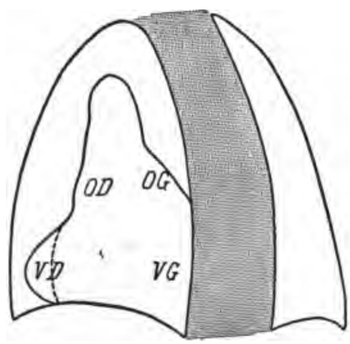

FIG. 37. LEFT ANTERIOR OBLIQUE POSITION, 50 DEGREES

The beam of x-rays penetrates the right back and comes out in the left mammillary zone, thus following the large axis of the heart. At the left of the figure, and consequently in the right lung, the outline of the right ventricle (VD) is seen, the shadow of which forms a considerable salience below the right auricle (OD). The dotted line indicates the normal ventricular contour.

IV. LEFT AURICLE

It is in the oblique positions that the degree of development of the left auricle can best be studied.

In the right posterior oblique, as in the left anterior oblique, the normal ray passing the posterior mediastinum is tangent to the margin of the left auricle.

When this auricle is hypertrophied or dilated, its contour develops behind and to the left of the heart and projects its shadow for some distance into the clear retro-cardiac space. The degree of enlargement of the auricular shadow is naturally proportional to the enlargement of the cavity. This deformation is very characteristic in simple mitral stenosis. However, the same obscurity of the retro-cardiac clear space may be produced by the presence of easily recognizable pathological pulmonary or pleural shadows, or by a considerable augmentation in the volume of the ventricle, which, besides, is rare in cases of mitral stenosis.

Fig. 38 illustrates a typical case of hypertrophy of the left auricle in right posterior oblique position at 50 de-

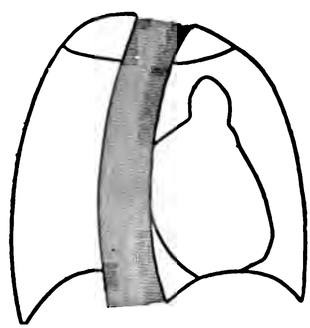

FIG. 38

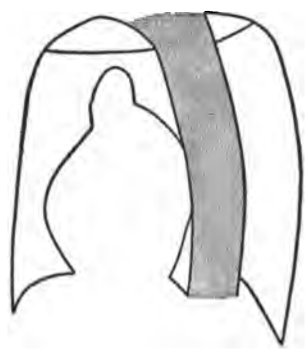

FIG. 39

FIG. 38. SIMPLE MITRAL STENOSIS

Right posterior oblique position at 50 degrees. The much enlarged left auricle casts a shadow which obscures part of the retro-cardiac clear space.

FIG. 39. SAME CASE, IN LEFT ANTERIOR OBLIQUE POSITION AT 50 DEGREES

grees. The salience which is noticed here and which lies in the postero-superior part of the cardiac shadow can only correspond to the left auricle; in the retro-cardiac clear space there is only a small transparent triangle included between the ventricular contour, the vertebral column and the diaphragm.

Examination in the left anterior oblique position leads to identical proofs and conclusions (Fig. 39).

The frontal position, without giving the same precise details, indicates, nevertheless, an increase of the median arc, especially manifest in its inferior portion which is at once salient and lowered in the region corresponding to the auricle (see Fig. 44. Mitral stenosis).

V. RIGHT AURICLE

The favorable position for the examination of the right auricle is the frontal, the oblique positions being only accessory.

In the frontal position the right auricle is in outline at the right of the sternum and its salience is increased as the auricle is increased in volume.

It is in the superior portion of its contour (at the level of the arrow in Fig. 40) that it can best be observed, for the right ventricle may, if it is hypertrophied or dilated, be noted projecting on the right side, but in the lower third or half of the shadow. In such circumstances, the auricle, pressed back and up, is visible only in the neighborhood of the superior vena cava. There is consequently always good reason for studying it in this high position. In case of doubt, the rhythms of the pulsations determine whether it is the auricle or the ventricle: the movements of presystolic retraction are due to the auricle, the movements of systolic retraction to the ventricle.

Figs. 40, 41, and 42 show a case of tricuspid insufficiency in which the right auricle is abnormally developed.

In Fig. 40, frontal position, will be noted the marked

development of the right heart area and the exaggeration of its curve in the upper half. In this place (at the level of the arrow) there were visible on the screen very clear movements of presystolic retraction which can be due to the auricle only.

Fig. 41, taken in the left posterior oblique position at 50 degrees, shows that the shadow of the right auricle effaces a part of the retro-cardiac clear space.

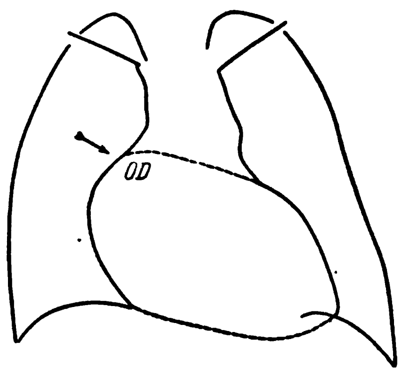

FIG. 40. TRICUSPID INSUFFICIENCY

In frontal position the shadow of the right auricle is much enlarged, especially in the zone indicated by the arrow.

Finally, in left anterior oblique position (Fig. 42) the contour of the right auricle describes a curve of large diameter projecting over the shadow of the right ventricle, which is contrary to what has been described in Fig. 37, where the ventricle is very large in relation to the auricle.

Sometimes the shadow of the right auricle may be increased without a corresponding increase in the volume of this cavity. This is a fact observed in mitral stenosis. It is explained by the elevation of the right cavities and their closeness to the sternum as a result of the marked development of the left auricle. The obliquity of the

heart from back to front is diminished; the projection of the auricle is increased as a result of the displacement of the organ and not because of its increase in volume.

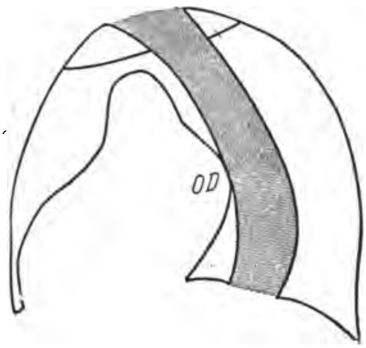

FIG. 41

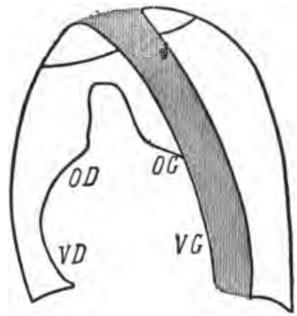

FIG. 42

FIG. 41. SAME CASE AS PRECEDING FIGURE, IN LEFT POSTERIOR OBLIQUE POSITION AT 50 DEGREES

In this position the shadow of the enlarged right auricle merges with the shadow of the vertebral column.

FIG. 42. SAME HEART AS IN FIGS. 40 AND 41, BUT IN LEFT ANTERIOR OBLIQUE POSITION AT 50 DEGREES

The outline of the enlarged right auricle (OD) makes a greater salient in the right lung than the left ventricle.

The preceding considerations concern the partial modifications in the volume of the heart in connection with the enlargement of one or another of the cavities. But it frequently happens in practice that several cavities are involved at the same time and to an unequal degree. New images then result, in which the radioscopic signs are combined. The study of these images gives, as will be seen presently, valuable assistance in the diagnosis and the prognosis of a large number of cardiac diseases.

CHAPTER IV

VALVULAR AFFECTIONS

VALVULAR lesions produce on the exterior form of the heart characteristic changes which are well known to pathologists. These lesions can often be interpreted during the life of the patient and most clinicians can readily distinguish at first sight a "mitral lesion" from an "aortic lesion." Sometimes they are not sufficiently characteristic to be obtained by the usual methods of diagnosis. The progress of radiography has been such that it has given the means of demonstrating the deformations of the cardiac outline even to the slightest detail and furnishing precise information for the diagnosis of valvular lesions.

SIMPLE MITRAL STENOSIS

Radiological diagnosis of mitral stenosis rests on two principal points: the volume of the left ventricle on the one hand, and that of the corresponding auricle on the other. The positions favorable for estimating them are: the direct anterior and the oblique.

EXAMINATIONS IN THE DIRECT ANTERIOR POSITION

Orthodiagrams of the heart in the frontal position or the direct anterior offer typical characteristics which are (see Fig. 43):

1. A considerable development of the left median arc, especially marked in the inferior portion.
2. A left ventricular outline of slight dimension.
3. A modification of the right contour, by an exaggera-

tion of the shadow to the right and by raising of its extreme points D and D′.

Left median arc. Examination of the mediastinal shadow outline on the left, from the clavicle to the diaphragm, shows that in most cases of mitral stenosis, the line of contour, after having marked the aortic half circle, takes an oblique direction from within outward to the heart apex. The outline shows only a notch, sometimes hardly perceptible, which corresponds to point G, at the level of which is observed the general seesaw movement of which this point constitutes the fixed axis. The phenomenon is here perfectly clear.

The point G lies lower than normal; it is much below point D which is opposite to it. The line which rises from G to the aortic arc thus limits the median arc which is exaggerated. The upper two-thirds of the outline, which constitutes the portion relatively the least salient, corresponds to the pulmonary artery and shows systolic movements of expansion; the lower third of the median arc, which bulges the most, corresponds to the left auricle and has only very feeble pulsations.

Left ventricular outline. The line GG′ which limits the shadow of the left ventricle is rather short and does not present, in most cases, a convexity as marked as in the normal state. The slight distension of this cavity explains why there is a decreased convexity of the walls.

Apex of the heart. The apex is near the left diaphragm. It generally appears as a rather acute angle, which leads Destot to state that in mitral stenosis "the apex of the heart is pointed." It is the more so, the greater the stenosis, and the smaller the left ventricle; when the stenosis is not very pronounced, the apex is slightly rounded as in the normal. It is always distinctly separated from the left thoracic contour, and is often pushed a little more inward and downward than in the normal state, but it does not follow from that that the ventricular contour is elongated, for point G, where the ventricular contour

Fig. 44. TELERADIOGRAPH OF SIMPLE MITRAL STENOSIS

begins, is itself lowered, so that the total length of the line GG′ does not change.

Right contour. The area of projection of the heart extends very noticeably beyond the right edge of the sternum. Its contour is shown by a curved line which deviates from the sternum at its origin (point D) and approaches it again near the diaphragm (point D′).

The right heart outline often takes, below D′, a vertical direction to the diaphragmatic shadow; it then limits the shadow of the inferior vena cava which is more visible than in the normal state.

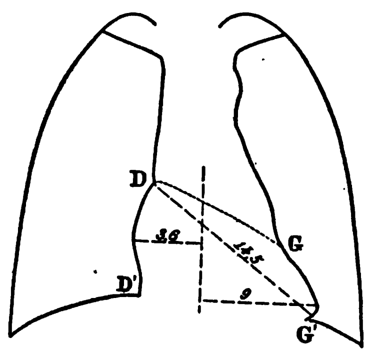

FIG. 43. SIMPLE MITRAL STENOSIS. WOMAN 52 YEARS OF AGE

The length of the line DD′ is generally greater than normal. By comparing it to the length of the left outline GG′, the relation of the two sides of the heart is established. Now, GG′ is, in a normal subject, greater than DD′, whereas in simple mitral stenosis GG′ but slightly exceeds, equals, or is even less than, DD′.

Diameters. The longitudinal diameter is usually exaggerated; this is due in part to the elevation of point D and in part to the lowering of the apex.

As for the horizontal diameter, it is, in spite of the development of the right area, always much less than the longitudinal diameter.

Clinical Cases. The diagrams which are published here are always comparable one with another.

Figs. 43 and 45 are cases of marked mitral stenosis. All the points emphasized in the foregoing are found, and here radiology only serves to confirm clinical findings.

Fig. 43 is of a woman fifty-two years of age, suffering from right hemiplegia with aphasia, supervening in the course of mitral stenosis, the diagnosis of which had already been made by Duroziez. Palpation gave a presystolic thrill very clear in the region of the apex; auscultation, a rhythm typical of mitral stenosis: diastolic rumble with presystolic reinforcement, the first sound rough, the second diminished. Further, percussion in the back, at the level of the left scapula gave rise to that peculiar pain, or auricular stitch in the side, which one of us has noted in patients with this affection.

The cardiogram shows in frontal position a marked increase in the median arc, whereas the outline of the left ventricle is almost normal. The area of the right auricle is exaggerated; the longitudinal diameter measures 14.5 cm. and the horizontal diameter, 12.6 cm. Finally, examination in the oblique position shows an increase in volume in the left auricle.

Fig. 45 is that of a young man twenty-four years of age of frail constitution, affected from infancy with mitral stenosis. This had caused an almost constant cyanosis of the extremities and dyspnœa so severe that the patient had to abandon his profession of violinist. Objective examination gave a marked presystolic thrill, and auscultation the characteristic signs of the lesion.

The cardiogram shows a very marked lowering of point G. The ventricular contour is almost vertical, but instead of being convex it is slightly concave. The left outline, GG′, measures 8 cm.; the right, DD′, is longer, measuring 9 cm.; the longitudinal diameter is 15 cm. and the horizontal 12.6 cm.

Fig. 46 is of a child eight years of age, with simple

mitral stenosis. The stenosis was of recent date. The cardiogram nevertheless is absolutely typical, showing that the lesion, though barely established, already had given the usual characteristics.

Fig. 47 is still more interesting. No heart affection was suspected by subjective signs and only auscultation gave a mitral rhythm, difficult to interpret, but suggesting a lesion. But it was unmistakably present as a radiological examination proved. The diagram demonstrates the exaggerated saliency of the median arc, the lowering of point G, and the excessive development of

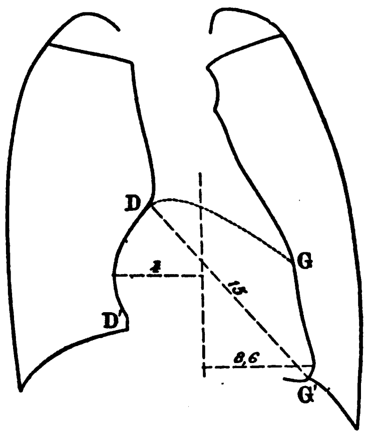

FIG. 45. SIMPLE MITRAL STENOSIS, MAN 24 YEARS OF AGE

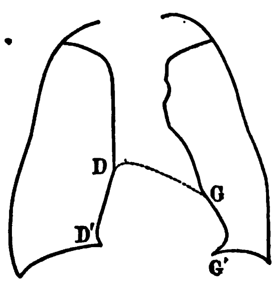

FIG. 46. SIMPLE MITRAL STENOSIS, CHILD 8 YEARS OF AGE

the right side of the heart. However, the apex of the organ is less acute than in the preceding cases. The left ventricular contour is a little convex as in the normal, but the relation of the outlines and the diameters is none the less modified in the manner expected. The left side, GG′, measures 8 cm., whereas the right side, DD′, measures 9.5 cm. The diameters are: longitudinal, 13 cm., horizontal, 8 cm.

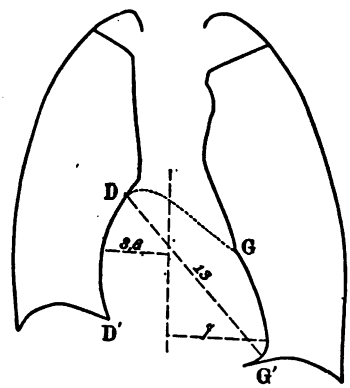

Fig. 47. SIMPLE MITRAL STENOSIS, NOT SEVERE. MAN 33 YEARS OF AGE

Interpretation of cardiograms and comparison with percussion. In the great majority of cases the tracings obtained by percussion agree with the radioscopic outlines (Fig. 48). The contour of the left side and the position of the apex with their precise form and location are shown. The smallness of the cardiac area on this same tracing corresponds to the underdevelopment of the organ, proved by precise radioscopy.

In simple mitral stenosis, therefore, the left ventricle is small, which agrees with the anatomical findings and clinical examinations made by Briquet, Merklen and by Potain and Rendu.

On this point clinicians are not all agreed and contend that in simple mitral stenosis the heart is increased in

volume. The argument advanced for this is that the apex is lowered and that its pulsations occur in the lower part of the fifth space, and even lower. This sometimes occurs, but is not conclusive evidence, and to judge the enlargement of the heart it is necessary to measure exactly the area of dullness. The area of dullness is not diminished, as is shown by the percussion and radiological outlines. The apex is displaced because, as has been said, the heart is lowered as a whole, and it is radiology that demonstrates this.

Radioscopy is superior to percussion in determining the development of the right side of the heart. Percussion gives only approximate information. Radioscopy is more precise, showing early a notable increase in size of the right cavities, while there are no symptoms, and compensation appears perfect. The numerous tracings that we have been taking and which are easy to interpret have given confidence. In mitral stenosis, the heart is lowered and at the same time undergoes a displacement from right to left, from behind forward, so that the right cavities are slightly raised towards the sternum. Examination of the projected images indicates this with certainty. In these conditions, the right curve of the heart must neces-

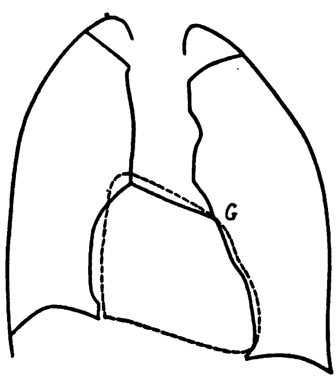

FIG. 48. SIMPLE MITRAL STENOSIS
Black lines, orthodiagram; dotted lines, percussion.

sarily be raised in the upper part to the level of the large vessels, as well as in the diaphragmatic portion, and shows an exaggerated development outside the sternum.

Thus in mitral stenosis the heart undergoes a slight double displacement; a movement downward which forces the apex below the normal position and a seesaw movement which pushes the right auricle toward the right, without a real enlargement of that cavity.

EXAMINATION IN OBLIQUE POSITIONS

Enlargement of the left auricle constitutes one of the principal changes in mitral stenosis. There is great interest in recognizing the existence and the degree of it. The method used up to the last few years was that of dorsal percussion suggested by Germe (Arras), which consists in percussing the area between the scapulæ and the vertebral column, between the fifth and tenth dorsal vertebræ and the left auricle. The zone of dullness thus outlined is limited in the normal but increases in marked degree when it is hypertrophied or dilated. But this method requires skill, and though the auricle is hypertrophied, it may not be near enough to the thoracic wall to give an appreciable change on percussion.

Radioscopic examination is preferable. Santiard[16] has reported a case of mitral stenosis in which posterior percussion did not show an enlargement of the left auricle. He states, however, that as shown by two radioscopic tracings outlined on the left of the heart, on the anterior image, a shadow was seen certainly produced by the dilated left auricle. On the posterior tracings, the hypertrophied auricle outlined above the ventricle is clearly visible.

Galli,[17] in 1908, published a tracing of mitral stenosis

[16] P. Santiard, *Étude de l'aire de projection du cœur sur la paroi thoracique par la radiographie. Thèse de Paris,* 1900, p. 57.

[17] G. Galli, *L'orthodiagraphia nella diagnosi delle malatti di cuore.* (Policlinico, partie méd., 1908, XV, 2.)

which shows a salient surmounting of the left ventricle, attributed to the projection of the enlarged left auricle, as the pulsations were clearly presystolic.

These examinations were made in direct position and do not solve the problem. The salience which was noted between the arch of the aorta and the origin of the left ventricle, that is, at the level of the median arc, corresponds not to the auricle but to the auricular appendage. The auricular salience is due in part to the fact that the auricular appendage is compressed by the hypertrophied auricle, in part to the lowering of the heart which puts a tension on the vessels, making the outline of the pulmonary artery more rectilinear, and finally to the underdevelopment of the left ventricle which makes the projection of the pulmonary artery and left ventricle more apparent. It is not surprising, therefore, that examination in the frontal position brings out the points mentioned by these investigators, which are, however, only indirect signs and more common in mitral stenosis.

The modifications found in the right posterior and the left anterior oblique positions are more important as they allow the contour of the left auricle to be marked more precisely towards the lower third of the retro-cardiac clear space. When it is hypertrophied or dilated, its outline is modified; it makes a greater salience than normally in the retro-cardiac area, its curve increases, approaches the shadow of the vertebral column and may even merge into it, the clear space ceasing to be visible at the level of the auricle.

To estimate exactly the importance of the development of the auricular shadow it is necessary to know the degree of obliquity of the body during the examination. In fact, according as the bi-scapular axis describes with the plane of the screen an angle of 45, 50 or 60 degrees, the retro-cardiac clear space is naturally larger and larger, and the outlines of the heart further from the vertebral column, so that in the first place an examination should be

made at 50 degrees. If at this angle the clear space is obscured, it may be concluded that the left auricle is enlarged; that it is considerably enlarged if the retro-cardiac clear area does not appear at an angle of incidence of 60 degrees. But in order that the examination should be conclusive, the pulmonary spaces should necessarily be transparent, which is not always the case in patients with mitral stenosis; it is necessary also that the region should not be obscured by pathological glandular or pulmonary shadows, by a tumor, or in the case of a woman, by large breasts.

Care should be taken that the patient raises his arms, and breathes deeply, and, in short, that the best possible conditions for the demonstration of the auricle be procured. If necessary, the examination should be made several times, the patient being moved until the best position is found and the angle of incidence of the body noted each time. Except in special circumstances, previously mentioned, the shadow of the auricle is finally always sharply outlined in the retro-cardiac clear space, and has only to be traced quickly at the moment when it is visible.

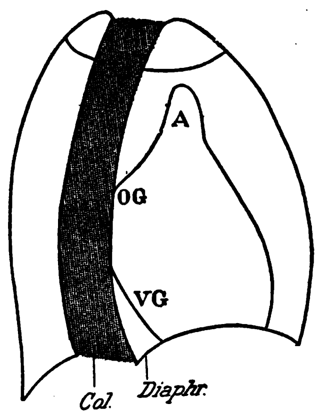

FIG. 49. RIGHT POSTERIOR OBLIQUE POSITION, 50 DEGREES

A, aorta; OG, left auricle; VG, left ventricle; *Diaphr.*, diaphragm; *Col.*, vertebral column.

The indications given by examination in the oblique position complete the radiological diagnosis of simple mitral stenosis.

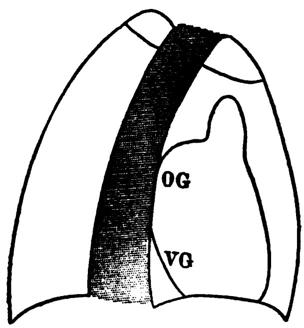

FIG. 50

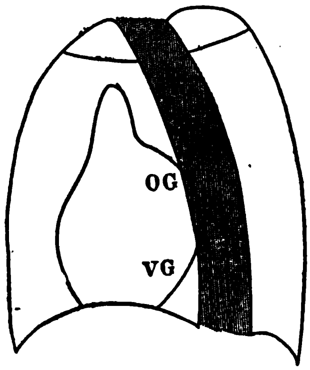

FIG. 51

FIG. 50. SAME CASE AS FIG. 45. RIGHT POSTERIOR POSITION, 50 DEGREES

FIG. 51. SAME CASE AS THE PRECEDING, IN LEFT POSTERIOR OBLIQUE, 50 DEGREES

Fig. 49 shows the same patient as Fig. 43, which gives the details of examination in the frontal position. It will be seen there that the greatly enlarged left auricle obscures with its shadow all the middle third of the clear space. In the lower part of this figure, the transparent triangle is found included between the lightly developed outline (VG), the vertebral column (*Col.*) and the diaphragm (*Diaphr.*). Above on the level of the aortic prominence (A), the clear space is readily distinguishable, but it soon ceases to be visible and the contour of the auricle joins the vertebral column.

The examination of Fig. 50 leads to the same conclusions. This figure is of a patient whose cardiogram in frontal position has been given in Fig. 45. Here the left auricle is still very large, as is shown in the tracings taken in the right posterior oblique and the left anterior oblique positions (Figs. 50 and 51).

Moreover, percussion showed enlargement of the auricle.

In Fig. 52 these points are less marked. The left auricle, it is true, is very much increased in size, since it forms a visible salient in the retro-cardiac space. However, its development is not as considerable as in the previous cases, for at 50 degrees there still exists a narrow, clear band between the shadow of the heart and that of the vertebral column.

Not all the tracings are as typical, and it will be understood that a moderate hypertrophy of the auricle does not cause the same deformations. However, to be convinced that the auricle is not normal, we have only to examine attentively the configuration of the curve which extends behind the origin of the blood-vessels, at the level of the diaphragm. It is seen that (Fig. 53) the highest point of this curve, instead of being at the level of the ventricle, corresponds to the level of the auricle; that is conclusive evidence that the auricle is increased in volume.

To sum up, every patient examined in the oblique position at 50 degrees who shows the shadow of the heart completely obscuring the retro-cardiac clear space at the height of its middle third, must be considered as having a

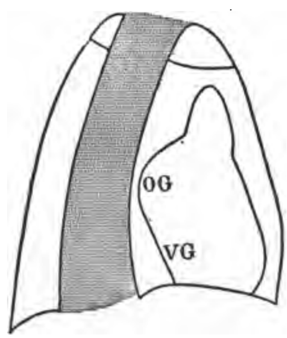

FIG. 52. SIMPLE MITRAL STENOSIS. RIGHT POSTERIOR OBLIQUE POSITION, 50 DEGREES. LESS ACCENTUATED ENLARGEMENT OF THE LEFT AURICLE

considerable hypertrophy of the left auricle. The degree of hypertrophy is measured by the extent of the reduction of the retro-cardiac clear space, a slight reduction corresponding to a moderate increase in the volume of the auricle, provided, of course, that the obscuring of the posterior mediastinum is not due to another cause.

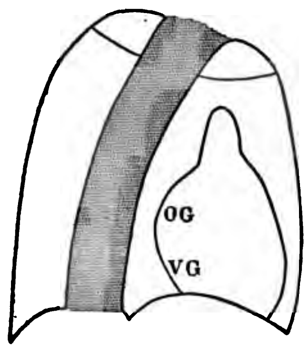

FIG. 53. RIGHT POSTERIOR OBLIQUE POSITION, 50 DEGREES. MODERATE DILATATION OF THE LEFT AURICLE

MITRAL INSUFFICIENCY

The clinical history of mitral insufficiency presents problems, the solution of two of which, at least, is not easy. The first is whether the systolic murmur heard at the apex belongs simply to the category of anorganic murmurs (Potain); the second is to recognize the cause of it, as the murmur may be symptomatic of a valvular lesion or of functional insufficiency. In this respect the indications furnished by semeiology are often uncertain and radiological examination may be of very great assistance.

The radiograms of a typical case of mitral insufficiency of rheumatic origin which has not given rise to marked circulatory disturbances will be studied first. This case is a patient twenty-five years of age, with a loud murmur heard at the apex of the heart during the whole systole

and transmitted toward the axilla. The affection began in adolescence (Fig. 54).

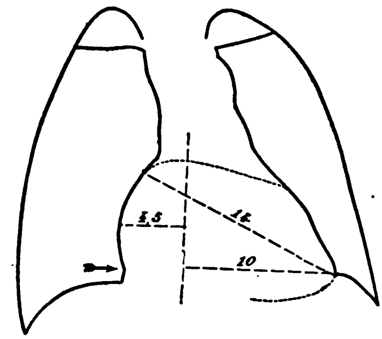

FIG. 54. MITRAL INSUFFICIENCY WITH COMPENSATION. MAN 25 YEARS OF AGE

The form of the area of projection somewhat resembles that of a normal horizontal heart, resting on the diaphragm. Its development, however, is clearly exaggerated on the right. Moreover, on the screen, pulsations could be seen in the vicinity of the diaphragmatic shadow (at the level of the arrow), which could only be caused by the right ventricle.

The contour of the left ventricle appears normal, its left point not elevated. The apex lies at the level of the left diaphragmatic shadow; it is not lowered, but pushed outward and rather pointed.

The changes seem to affect only the right heart area and this is confirmed by the measurement of the diameters: longitudinal diameter, 14 cm.; horizontal diameter, 14.5 cm.

The longitudinal diameter does not exceed the normal for a man twenty-five years of age, of average weight, but the horizontal diameter is 5 mm. greater than the longitudinal: this difference confirms the radiological diagnosis, which is a transverse enlargement of the heart due to the development of the right cavities.

In the right posterior oblique position, moreover, the apex of the heart disappeared behind the shadow of the vertebral column only at an angle of 42 degrees instead of at 25 to 30, the normal figure. That could be explained only by a ventricular enlargement in which the left ventricle was involved to a certain extent but less than the right.

Finally, in the oblique position the left auricle did not appear to be changed.

These signs agree with the pathological findings which show that in mitral insufficiency a slight hypertrophy of the left ventricle exists, an insignificant enlargement of the right ventricle which varies with the severity of the symptoms. It is not surprising, therefore, that the ventricles are accentuated when mitral insufficiency is complicated with dyspnœa, cyanosis, œdema of the extremities, etc. (See Fig. 55.)

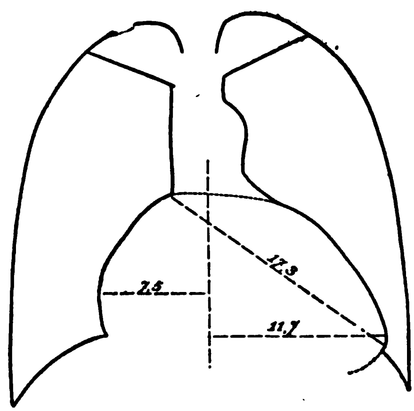

FIG. 55. MITRAL INSUFFICIENCY. MARKED ENLARGEMENT OF THE RIGHT HEART. MAN 34 YEARS OF AGE

This shows that the heart is greatly enlarged and that the enlargement is of the two ventricles, principally the right. On the left, the ventricle bulges, its contour is

elongated, its apex pushed out but not lowered and on the other side the salience of the shadow corresponds to the lower part of the contour or to the region of the right ventricle, and further evidence is the presence at this point of systolic pulsations. The two diameters measure: horizontal, 19.2 cm.; longitudinal, 17.3 cm., instead of 14. Both, then, have increased, especially the horizontal, which denotes a generalized hypertrophy, but predominant on the right.

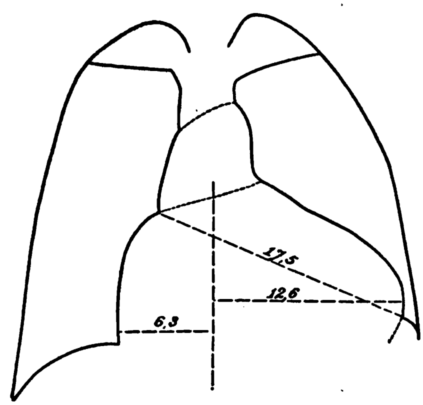

FIG. 56. MITRAL INSUFFICIENCY. ASYSTOLIC PERIOD

Fig. 56 shows a patient with confirmed asystolic changes in which these characteristics are still more accentuated. The transverse enlargement of the heart is considerable; it is very much lowered on the right where its greatly elongated contour deviates progressively from the median line to the level of the diaphragm. The apex is elevated and pushed to the left, toward the thoracic wall. Both diameters are increased and the horizontal is much greater than the longitudinal. On the screen pulsations were seen to be very feeble, especially in the right ventricular area.

In these cases, radiological examination only confirms an evident diagnosis. There are other cases in which the clinical signs were less clear and in which radiological examination nevertheless gave the same results.

Orthodiagram 57 is of a woman who had an apical systolic murmur but who showed no functional trouble that would indicate a cardiac lesion.

By fluoroscopic examination there seemed to be no notable modifications. The diameters measured: horizontal, 10.5 cm.; longitudinal, 11.2 cm., about the normal

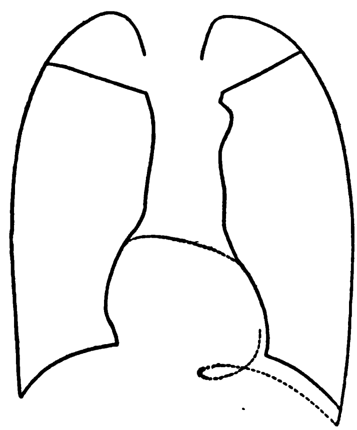

FIG. 57. SLIGHT MITRAL INSUFFICIENCY. WOMAN 32 YEARS OF AGE

figures. However, the right outline was slightly exaggerated, and in deep inspiration the inferior contour of the heart clearly projected over the diaphragm, which could be explained only by an enlargement of the right ventricle. Moreover, by goniometer readings, the apex disappeared behind the shadow of the vertebral column only at an angle of 40 degrees. The heart, therefore, was pathological, and the changes found, such as an increase

of the right contour, lowering of the inferior margin of the corresponding ventricle, disappearance of the apex at too great an angle of incidence, proved that a moderate but indisputable enlargement of the heart, especially of the right ventricle, existed, indicating mitral insufficiency.

These proofs are of practical importance in relation to differential diagnosis of systolic murmurs of the apex, which is at times difficult. Frequently these kinds of murmurs are of anorganic nature and their characteristics are not always clear enough to distinguish them. They occur less frequently than as stated by Potain for the reason that functional murmurs were not included. If a mitral lesion, however well compensated, were always accompanied by changes visible on the radioscopic screen, the question would be settled. This is not absolutely so, but nevertheless radiological examination does give valuable information in this respect. It may be considered in the following manner:

Any patient who by radiological examination shows no abnormal heart changes, no increase in the volume of the ventricular cavities, must be regarded as free from lesions of insufficiency, irrespective of the results of clinical examination. On the other hand, any patient in whom auscultation reveals the existence of a murmur, the nature and position of which would tend to put it in the category of anorganic sounds, should be suspected of mitral insufficiency, if radiological examination demonstrates all or part of the changes previously described.

The accuracy of these statements has often been verified. In individuals with a superficial anorganic murmur, constantly varying with change of position, radiological examination has not shown any heart changes, and when the murmur did not present these characteristics, investigation, at first not convincing, finally showed a slow but progressive enlargement of the volume of the heart which enabled a diagnosis to be made which had previously been questionable.

FUNCTIONAL MITRAL INSUFFICIENCY

Another interesting question is to determine the nature of a mitral insufficiency which has been recognized by the usual clinical signs and by radiological examination.

Mitral insufficiency does not always have the same origin. It results either from an endocarditis, or from a sudden or slow dilatation of the left ventricle; in this case it may disappear under the influence of appropriate care and treatment, or may continue indefinitely. This latter type of insufficiency is called functional. Its diagnosis, often difficult, depends on anamnesis, the habitual but not constant presence of an arterial hypertension or galloping sound, and especially on the percussion and palpation findings which reveal a considerable increase of the left ventricle. These signs, however, are not always conclusive, and radioscopic examination is then of great assistance. Here is an example:

A patient forty-six years of age, subject for two years to dyspnœa on exertion, had been in the hospital in 1908 and in January, 1910, for suffocating attacks of an œdematous nature. In March, 1910, he entered our department, with a similar attack which yielded to a copious phlebotomy. Examination showed that the heart was enlarged and dilated, and that at the apex there was, together with a very clear purring thrill, a somewhat modified systolic murmur, superficial, rather rough and lying below and within the heart apex. Arterial pressure was 15 cm. by sphygmometer. The urine contained a considerable quantity of albumen.

The logical diagnosis from these findings should be as follows: mitral insufficiency with beginning cardiac insufficiency. The principal points of the case, notably the pulmonary œdematous attacks and the absence of peripheral œdema, are not explained. Finally, no history of infectious disease was found which could have given rise to mitral endocarditis.

Radioscopic examination gave, on the other hand, valuable information (Fig. 58).

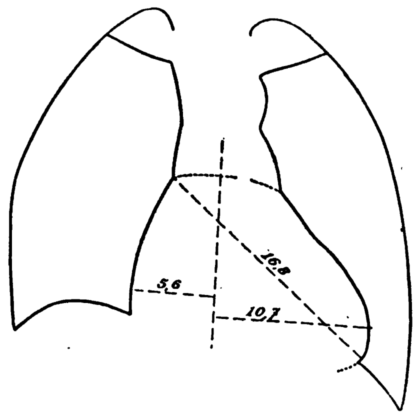

FIG. 58. FUNCTIONAL MITRAL INSUFFICIENCY. MAN 46 YEARS OF AGE

It enabled recognition at once of the ordinary signs of mitral insufficiency: apex slightly lowered but pushed outward, with enlargement of the right ventricle; it showed, moreover, certain anomalies. The contour of the left ventricle was more marked than in cases of endocarditic mitral insufficiency; the apex, instead of being pointed, was rounded, slightly globulous. Finally, the longitudinal diameter measured 16.8 cm., while the horizontal was only 16.3 cm., so that there was a difference in favor of the longitudinal diameter contrary to what we have indicated in the foregoing.[18]

In conclusion, in estimating the total increase in the volume of the heart, hypertrophy of the left ventricle played a much greater part than in the case of simple mitral insufficiency.

The impression derived from clinical examination,

[18] In analogous cases the figure of the index of depth is singularly instructive; it rises to 20, 25 centimeters and even more, which indicates marked enlargement of the left ventricle.

namely, that it was a mitral insufficiency of functional origin, was therefore confirmed.

The evolution of symptoms soon showed that this was correct. After some days of rest, the patient having been placed on a milk diet and treated with digitalis, the disturbances steadily diminished. The murmur at the apex disappeared and was replaced by a galloping rhythm in the left preventricular region.

It was not a cardiac but a cardio-renal case and this conclusion was due to radiological examination. The diagnosis could therefore be made: cardiac hypertrophy, dilation of the left heart, functional mitral insufficiency in a patient with renal sclerosis.

The case shown in the following tracing (Fig. 59) gave rise to the same problem which was solved in the same way. The patient was a man fifty-three years of age with mitral insufficiency due in the absence of previous infections to a generalized alteration of the arterial system.

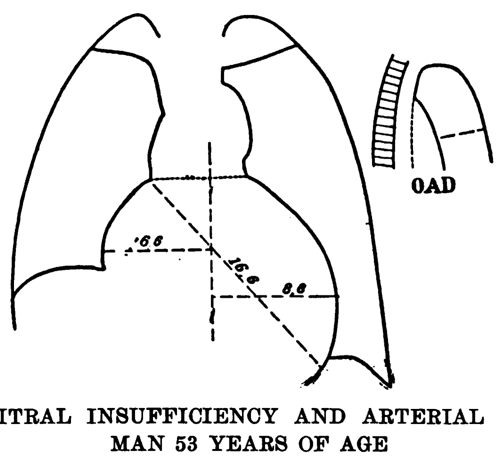

FIG. 59. MITRAL INSUFFICIENCY AND ARTERIAL SCLEROSIS. MAN 53 YEARS OF AGE

Radioscopic examination showed a considerable enlargement of the left heart, the apex was lowered and rounded, the right ventricle bulged a good deal to the

right, the diameters measured: horizontal, 15.2 cm.; longitudinal, 16.6 cm.—a deviation the inverse of what is seen in endocarditic mitral insufficiency. The aorta, moreover, was very much dilated, its walls were dense, and pulsations feeble. These findings proved that the patient was affected with cardio-vascular sclerosis and that mitral insufficiency was only a secondary symptom developed in the course of his affection.

MITRAL DISEASE

There are cases in which the radiological tracing is sufficiently characteristic in itself to justify the suspicion of a lesion apart from the clinical examination of the patient. The following is an example:

A young woman was seen by one of us at the request of a colleague who had previously made an orthodiagraphic examination of the patient's heart. The whole pathological history was clearly presented. The heart and the auricle showed deformations which could be explained only by a double mitral lesion. Moreover, the very visible increase of the contour of the right ventricle presupposed the existence of marked failure of compensation, so that before we saw the patient the following diagnosis was justified: mitral stenosis complicated with insufficiency, together with cardiac insufficiency—which clinical examination confirmed.

This method of procedure is not difficult and with little experience the interpretation of orthodiagraphic tracings can be made. Fig. 60 illustrates this.

It is seen here that in the frontal position the point G is surmounted by a salience and that the right contour shows an unusual development. These are characteristics peculiar to mitral stenosis. In the oblique position, it is necessary to put the patient at an angle of 60 degrees in order that the retro-cardiac clear space should appear as a narrow band in which a shadow is seen, due to the

hypertrophy of the left auricle (Fig. 61). These are the particular characteristics of mitral stenosis.

In direct position, the apex, moreover, is not sharp as in simple mitral stenosis; it is rather rounded and is depressed below the diaphragm and during deep inspiration the inferior contour of the heart is below the diaphragmatic shadow. Finally, in determining at what angle the apex of the heart disappears behind the shadow of the

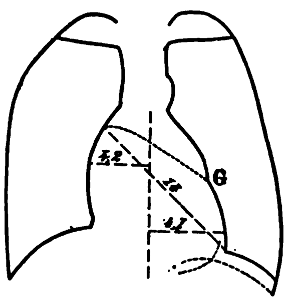

FIG. 60

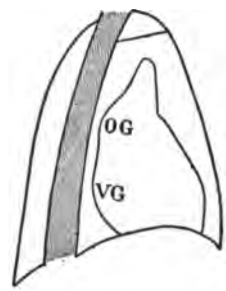

FIG. 61

FIG. 60. DOUBLE MITRAL LESION. GIRL 11 YEARS OF AGE

FIG. 61. SAME PATIENT. DOUBLE SALIENCE OF LEFT AURICLE AND OF LEFT VENTRICLE IN RIGHT POSTERIOR OBLIQUE POSITION, 60 DEGREES

vertebral column, it is found to be 45 degrees, a high figure and indicating that the left ventricle is enlarged. A further proof of this is that in left posterior oblique position at 60 degrees the ventricle projects below the left auricle in the retro-cardiac clear space.

In this tracing, changes are found which belong on the one hand to mitral stenosis and on the other to insufficiency. This diagnosis was further confirmed by the clinical findings, as the patient had a purring thrill at the apex, a diastolic rumble and a presystolic and systolic murmur.

The increase in the volume of the left auricle and the hypertrophy of the left ventricle, which with double

mitral lesions give special radioscopic findings, are seen in all cases of mitral disease. Figs. 62 and 63, a patient

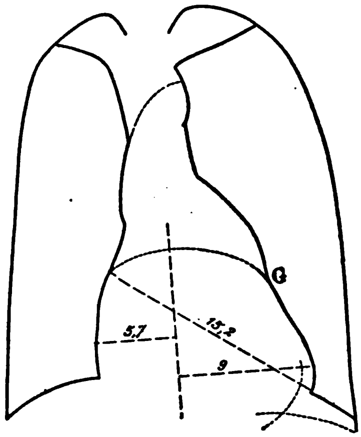

FIG. 62

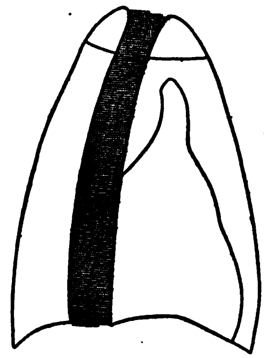

FIG. 63

FIG. 62. DOUBLE MITRAL LESION IN THE ACUTE STAGE. MAN 20 YEARS OF AGE

FIG. 63. SAME PATIENT, IN RIGHT POSTERIOR OBLIQUE POSITION, 40 DEGREES

with double mitral lesion in the acute stage, can be interpreted in the same manner.

In the frontal position (Fig. 62), a salience of the left median arc and a notable enlargement of the left ventricle are seen; the diameters of the heart are exaggerated, the longitudinal measures 15.2 cm., and the horizontal, 15.7 cm. In right posterior oblique position (Fig. 63), the retro-cardiac clear space is completely obscured by the left auricle and the left ventricle shadows.

These characteristics are somewhat modified when the cardiac lesion is complicated by asystolic phenomena; the right ventricle then plays a more and more important part in the enlargement of the heart, its lower contour makes a salient which is greater according as there is more hypertrophy or dilatation of the ventricle, while

the apex of the heart is pushed outward. The index of depth shows in a clearer manner the degree of posterior development of the heart. Examinations in the oblique position confirmed these findings.

But what is more, sometimes radioscopic examination determines the respective part played by stenosis and insufficiency in the case of a double mitral lesion.

Fig. 64 shows a girl eight years old in whom auscultation gave all the signs of a similar affection, and it shows what clinical examinations could not discover, that mitral stenosis had much more to do with the case than insufficiency.

In the frontal position, the median arc is much exaggerated. Point D is elevated; the upper portion of the right contour is abnormally developed. Here are all the signs of a marked dilatation of the left auricle. On the other hand, the left ventricle is moderately enlarged, for if the apex does not separate from the diaphragm during deep inspiration, it disappears in the right posterior oblique position behind the vertebral column only at a slightly greater angle than normal.

In the right posterior oblique position at 50 degrees (Fig. 65), the auricle is very large and completely ob-

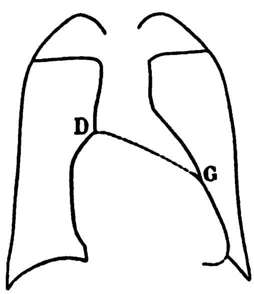

FIG. 64

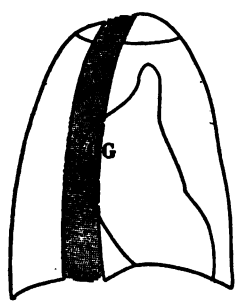

FIG. 65

FIG. 64. DOUBLE MITRAL LESION WITH MITRAL STENOSIS PREDOMINANT. GIRL 8 YEARS OF AGE

FIG. 65. SAME CASE, IN RIGHT POSTERIOR OBLIQUE, 50 DEGREES

scures the retro-cardiac clear space. The shadow of the left auricle is not large, for the lower part of the retrosternal space is visible as a small transparent triangular zone. The conclusion is decisive, and if there is a double mitral lesion, stenosis is more marked here than insufficiency.

Radiological examination has allowed the objectifying of deformations of the heart due to the regular evolution of a mitral lesion, and also those which are the result of superadded complications. These may have various origins.

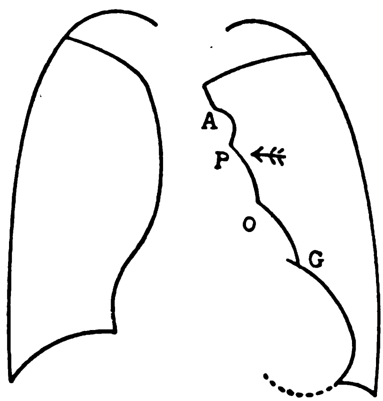

FIG. 66. PULMONARY INSUFFICIENCY COMPLICATING MITRAL DISEASE

Exaggeration of the pulmonary arc. Heart "*en sabot.*"

They result either from mechanical disturbances or from the secondary localization of infectious processes at the site of the regions previously affected.

Stell in 1886, and again in 1906, called attention to the curious fact, that mitral lesions, especially stenosis, could provoke, following increase of pressure in the smaller vessels, an insufficiency of the pulmonary orifice of functional nature, demonstrated by a soft diastolic murmur, heard along the left border of the sternum. Since then

further cases have been reported and we have also examined a certain number. This association adds a difficulty to the diagnosis, since the diastolic murmur may reasonably be considered symptomatic of an aortic lesion. Radioscopic examination, however, removes all doubt respecting diagnosis. Fig. 66 demonstrates this.

The case is that of a woman with a double mitral lesion, stenosis being predominant over insufficiency. This patient had had several attacks of severe dyspnœa which were later less severe when a new sign appeared, a diastolic murmur with the characteristics previously indicated, undoubtedly due to pulmonary insufficiency. The proof of it is furnished by the orthodiagram in question. A marked development of the pulmonary arc is seen, a notable dilatation of the right cavities giving the heart the appearance of the *"sabot"* which is usual in lesions of the right heart. The configuration bears no resemblance to what is found in aortic lesions.

Pulmonary insufficiency, however, may still be manifested, as Lutembacher[19] has noted, in the course of one of those variations of secondary subacute endocarditis which are common among cardiacs. In the case which we are considering, the inflammatory process is not confined to the endocardium, but extends to the pulmonary circulatory system and gives rise to a pulmonary endarteritis with embolism or thrombosis, which on auscultation is accompanied first by an exaggeration of the second pulmonary sound, then by a diastolic murmur characteristic of functional insufficiency of the orifice.

On the radioscopic screen, changes identical with those which have just been indicated are noted. The only difference consists in this, that they develop rapidly, the pulmonary arc presenting, at least in the course of a few days, a great exaggeration of its diameters (Fig. 67).

As is readily seen, radioscopic images are not always

[19]R. Lutembacher, *Endocardite subaigue chez les cardiaques.* (Archives des maladies du cœur, des vaisseaux et du sang, août, 1917.)

the same in cases of mitral lesion, but their dissimilarity is due to the fact that the anatomical configuration of the heart is modified according to the type and degree of the lesion. These images enable the diagnosis to be confirmed and, in a certain measure, the progress of the lesion to be followed; but in order to be able to interpret them properly, it is necessary to have at the same time a complete clinical and radiological knowledge.

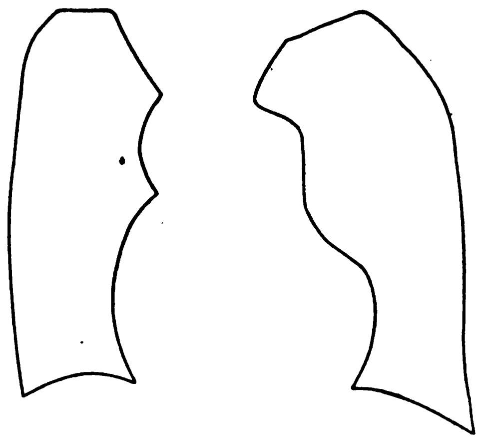

FIG. 67. PULMONARY INSUFFICIENCY IN THE COURSE OF A SECONDARY SUBACUTE ENDOCARDITIS

Exaggeration of the pulmonary arc. Heart *"en sabot."*

AORTIC INSUFFICIENCY

The two principal types of insufficiency will be studied: endocarditic aortic insufficiency and aortic insufficiency, either arterial or subsequent to changes of the vessel, extending to the semilunar valves.

ENDOCARDITIC AORTIC INSUFFICIENCY

Fig. 68 is of a patient with typical aortic insufficiency, of rheumatic origin, with as yet no serious failure of compensation.

It shows the shadow of the heart occupying a somewhat median position and the apex, which is lowered, only slightly pushed outward; moreover, it is rounded and is not separated from the left diaphragm during forced inspiration. The general form suggests somewhat a purse, the bottom of which would correspond to the heart apex.

The contour of the left ventricle is elongated, convex, but not exaggerated. Point G, though not very abnormally elevated, lies a little too high, being on the same line as the corresponding point D. Finally, the whole length of the left outline shows systolic pulsations of marked amplitude and force.

The right contour is normal and this contour, moreover, is not modified except at the period when functional disturbances appear; the presence of systolic pulsations, perceptible rather high above the diaphragm, does not necessarily indicate hypertrophy or dilatation of the ventricle to the right; it may simply mean that the ventricle is pushed back as a result of the lowering of the heart and its displacement toward the median line, because of the weight of the left ventricle.

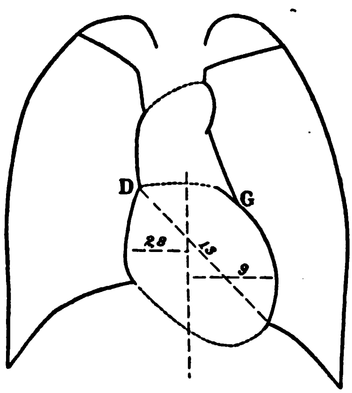

Fig. 68. AORTIC INSUFFICIENCY. PERIOD OF COMPENSATION. MAN 40 YEARS OF AGE

Finally—and this agrees with the preceding data—the longitudinal diameter exceeds the normal, and the horizontal diameter is decidedly less.

In the right posterior oblique position (Fig. 69), the apex of the heart disappears behind the vertebral column only at a wide angle, a fact which is easily explained, if it is granted, as has been shown, that hypertrophy of the left ventricle in its early stage affects the mediastinal area. Sometimes the enlargement is so slight that it can be shown only by determining index depth.

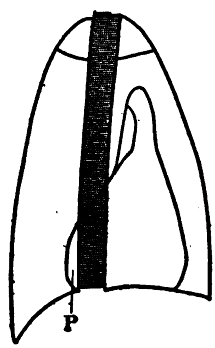

FIG. 69. SAME CASE, IN RIGHT POSTERIOR OBLIQUE POSITION

At an angle of 40 degrees, the apex of the heart has not yet disappeared behind the vertebral column.

The preceding images, therefore, lead to the conclusion that the patient is suffering from marked hypertrophy of the left ventricle without involvement of the other cavities. This view of the heart is characteristic of severe aortic insufficiency when it has not yet given rise to grave symptoms. It is necessarily completely modified when it is caused by asystolic disturbances which provoke secondary deformations of the other cardiac cavities.

The hypertrophy of the left ventricle is sometimes so slight in the course of aortic lesions that it might easily escape attention if recourse were not had to the different

Fig. 70. TELERADIOGRAPH OF AORTIC INSUFFICIENCY

methods indicated. In this case we might conclude that the heart is normal and if clinical signs are not characteristic, admit that valvular cardiopathy does not exist. The following is an example.

On auscultation, the patient gave a rather accentuated diastolic murmur at the aortic area but of questionable character. In the frontal position orthodiagraphic examination showed no pathological characteristic; the diameters of the cardiac shadow were normal; the apex was a little low and globulous. It was insufficient to prove, however, that the left ventricle was enlarged. Yet the index of depth was slightly but definitely exaggerated. Finally, in the right posterior oblique position it was necessary to place the patient at an angle of 35 degrees (instead of 30, the normal figure) to cause the apex to disappear. After that it was necessary to revise the negative conclusions of the examination made in the frontal position. The globulous form of the apex, the exaggeration of the angle at which it ceased to be visible in right posterior oblique position, the increase in the index of depth, were sufficient evidence that hypertrophy of the left ventricle existed, slight, it is true, but indisputable.

On the contrary, there are cases in which aortic insufficiency, however well compensated, is accompanied by a considerable ventricular hypertrophy readily perceptible by the ordinary methods of radiological examination. The teleradiogram (Fig. 70) is a typical case. The appearance of serious functional disturbances only increases ventricular hypertrophy, which may attain excessive dimensions, as shown in Fig. 71.

Radiological examination is able also to demonstrate the coexistence with aortic insufficiency of valvular cardiopathy, notably of mitral stenosis. This is interesting, for it has been assumed, for purely theoretical reasons, that the association of these two lesions was a rather favorable condition. But in the great majority of cases

the coexistence of a mitral stenosis with aortic insufficiency has been based only on the presence of a presystolic murmur at the level of the apex. This is not sufficient, and today we know that simple aortic insufficiency is often accompanied by a murmur which has nothing to do with mitral stenosis and which is due exclusively to intra-ventricular circulation provoked by the reflux of the

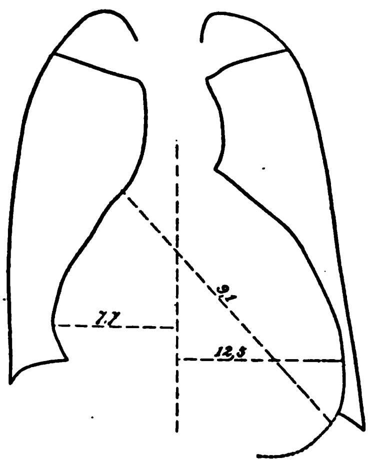

FIG. 71. AORTIC INSUFFICIENCY, ASYSTOLIC PERIOD

Considerable hypertrophy of the left ventricle, dilatation of the right cavities.

blood; what has been known as Flint's murmur. It is not surprising that aortic insufficiency accompanied by a murmur should generally be a favorable prognosis, for aortic insufficiency alone is not accompanied by any other lesion. On the other hand, where there is a combination of aortic insufficiency and mitral stenosis, the prognosis is always more serious. In pathology as in arithmetic, one and one make two, and an isolated lesion of the heart entails less risk than a double lesion.

But how shall it be determined whether aortic insufficiency is complicated with mitral stenosis, when the most

characteristic sign of this latter affection, the murmur, is found in both cases? There is only one way of deciding it: that is to determine the volume of the left auricle, which is always increased in the case of mitral stenosis, and is normal, contrary to what Potain and Rendu have said, in aortic insufficiency alone. It is difficult to estimate the volume of the left auricle by the ordinary means of examination, and the method of dorsal percussion employed is not always successful, whereas radiology gives conclusive information (see Fig. 72).

Fig. 72 is of a patient who showed positive signs of aortic insufficiency and signs which gave the impression without affirming it, that a mitral stenosis was also present. The view of the heart in the frontal position recalls, indeed, what is found in aortic insufficiency. The left ventricle is greatly enlarged and the right contour is almost normal. The apex of the heart is pushed out but not elevated; it is rather lowered, rounded and globulous. To this should be added the fact that the left ventricle

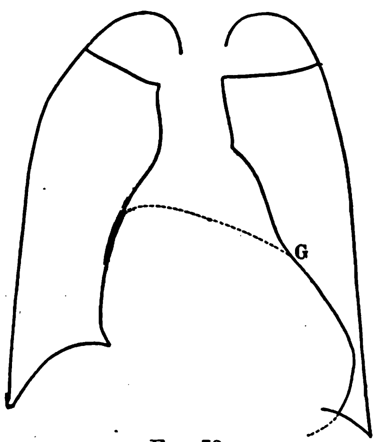

Fig. 72

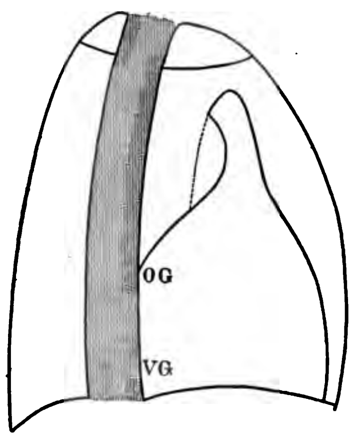

Fig. 73

Fig. 72. AORTIC INSUFFICIENCY AND MITRAL STENOSIS

Fig. 73. SAME CASE, IN RIGHT POSTERIOR POSITION, AT 50 DEGREES

pulsations showed in the course of radioscopic examination an unusual amplitude.

On this same tracing, however, the median arc is seen to be increased, which leads to the supposition that the auricle must be abnormally developed.

In the right posterior oblique position (Fig. 73), this last sign becomes clear. It is seen that in the retrocardiac clear space is a shadow due in part to the left ventricle, and in part also, in the upper region, to the auricle. For this to occur, the auricle itself must necessarily be enlarged. Both examinations then showed that there was indeed a combination of the two lesions: aortic insufficiency and mitral stenosis.

AORTIC INSUFFICIENCY OF ARTERIAL ORIGIN

In the preceding cases aortic insufficiency constituted, as stated, the entire disease, the aorta presenting no changes. This type of lesion, relatively favorable, is consistent with a more or less long life. But it is not the case with a valvular lesion when it coincides with extensive changes in the vascular system, principally of the aorta, and the prognosis then is entirely different. It is always important to know exactly the condition of the aorta in cases of aortic insufficiency. Radioscopy furnishes in such cases more information than other methods of examination.

The orthodiagram in Fig. 74 is of a man fifty-three years of age, with a diastolic murmur at the base characteristic of aortic insufficiency. This lesion did not cause much disturbance. The preceding year, however, following common grippe, severe symptoms of cardiac failure appeared without any history which might explain the cause of a valvular lesion. The supposition was correct then, that it must be of arterial origin, although palpation and percussion did not show enlargement of the aorta.

Orthodiagram 74 confirms the diagnosis of aortic in-

sufficiency. It is seen here, that in the frontal position the left contour is elongated and dilated, that the apex is rounded and lowered, which is evidence of serious ventricular hypertrophy. Examination of the aortic outline, moreover, shows that the vessel is dilated at its

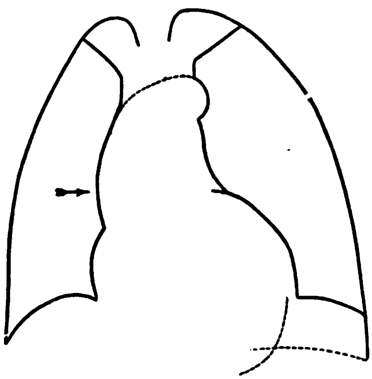

FIG. 74

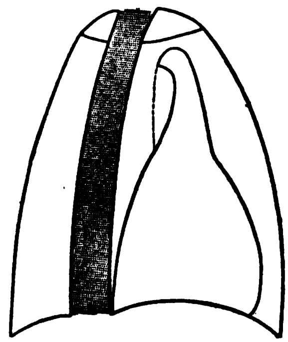

FIG. 75

FIG. 74. AORTIC INSUFFICIENCY WITH DILATATION OF THE AORTA AT ITS POINT OF ORIGIN. MAN 53 YEARS OF AGE

FIG. 75. SAME PATIENT IN RIGHT ANTERIOR OBLIQUE POSITION AT 45 DEGREES. THE CALIBER OF THE AORTA IS LARGER AT THE ORIGIN THAN AT THE LEVEL OF THE ARCH

origin from the valvular ring to the level of the arch where it resumes its normal caliber. On the right it projects over the sternum, and at this point (at the level of the arrow) the aortic shadow shows very ample pulsations.

In the right anterior oblique position (Fig. 75), the aortic shadow assumes the form of a cone, the largest part of which corresponds to the base of the heart.

The conclusion from the examination of these two figures is that there was aortic insufficiency, as auscultation indicated, but that this lesion was, so to speak, only an epiphenomenon occurring in the course of aortitis.

In the following case (Fig. 76), the clinical and radio-

scopic signs were still more emphasized. A man thirty-nine years of age with Hodgson's disease, presenting serious functional disturbances: dyspnœa on exertion, vertigo and anginose attacks. The tracing shows in the frontal position a considerable enlargement of the area of projection of the heart. The longitudinal diameter measures 16 cm., the horizontal, 13.2 cm.; the apex is

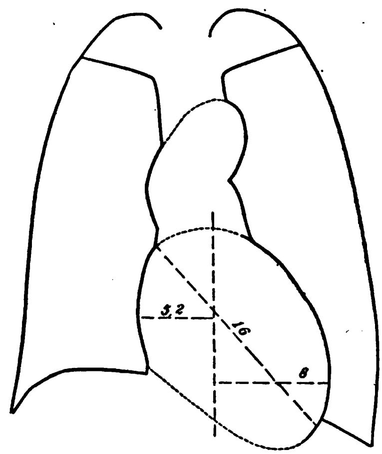

FIG. 76. AORTIC INSUFFICIENCY OF ARTERIAL ORIGIN. MAN 39 YEARS OF AGE

rounded and lowered. In the right posterior oblique position it disappears behind the vertebral column only at an angle of 48 degrees. On the screen the left contour of the heart, greatly enlarged, showed ample pulsations; the ascending portion of the aorta was dilated, tortuous, dense, and at each systole the arch as a whole showed forcible pulsation.

There were found characteristics of both lesions: aortitis and valvular insufficiency. But these lesions were accompanied, besides, by an interesting peculiarity. Whereas in cases of simple aortitis the vascular contour

is much reduced in its rhythmic expansion, because of the thickening of the arterial walls, here, on the contrary, the arch was animated at each systole by forcible pulsations. The forcible contraction of the left ventricle displaced the arch entirely, and these displacements were especially noticeable in the left superior arch. This showed that the aorta but feebly resisted the pressure of the blood.

AORTIC STENOSIS

Anatomical findings in cases of aortic stenosis suggest that the changes in the heart ought to be similar to those of aortic insufficiency. These changes should consist of an even more marked enlargement of the left ventricle and in the frequent coexistence of lesions of the aorta. That is in point of fact what is found in the tracings.

Orthodiagram 77 is of a patient forty years of age with serious aortic stenosis, with no sign of cardiac insufficiency. The point to be noted here is the excessive development of the volume of the heart; the longitudinal diameter measures 17.5 cm.; the horizontal, 17.8 cm.; the aorta shows no lesion. In this case the clinical diagnosis was apparent and radioscopy confirmatory.

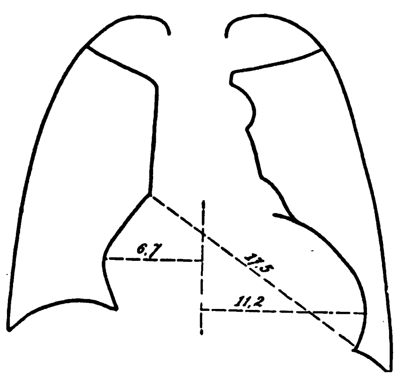

FIG. 77. AORTIC STENOSIS WITHOUT AORTITIS. MAN 40 YEARS OF AGE

It is not always so. Often it is difficult to know whether or not aortic stenosis exists, for the systolic murmur at the base is difficult to interpret, and hypertrophy of the left ventricle always present in this disease is not sufficiently marked to be obtained by palpation or percussion. It is in such cases that radiology is most effective, and several times in debatable cases, aortic stenosis had to be determined by the single fact that screen examination demonstrated the presence of a left ventricular hypertrophy.

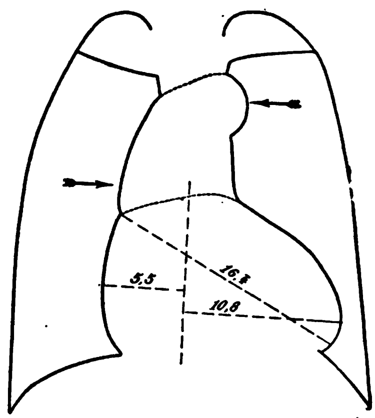

FIG. 78. AORTIC STENOSIS. DILATATION AND FORCIBLE PULSATION OF THE AORTA. YOUTH 17 YEARS OF AGE

This examination leads to other findings which have an important bearing on the prognosis of aortic stenosis, which varies according as the lesion is simple or accompanied by more or less extensive changes of the aorta. These findings should be interpreted with great care, as the following case shows.

A youth seventeen years of age affected with aortic stenosis as shown by a systolic murmur at the base. The orthodiagraphic tracing (Fig. 78) confirmed the diagnosis, for all the objective signs were characteristic. On

superficial examination, it might have been thought that there were at the same time marked lesions of the vessel, which would have given an unfavorable prognosis. In the frontal position, an evident enlargement of the arch was observed, its total transverse diameter being 7.5 cm. instead of 4 or 5 cm., the normal figure. However, in the right anterior oblique position the enlargement was barely appreciable, for the diameter of the aorta measured only 2.2 cm., which is but a slight deviation from the physiological. On the screen, the arch of the aorta was greatly dilated at each systolic pulsation and in the course of full pulsations its walls deviated 5 or 6 mm. from their normal position of rest. The necessary conclusion, then, was that the increase in volume of the aorta was due to a functional dilatation rather than to a permanent dilatation, that the arterial walls had retained all their elasticity, which led to a revision of the dubious prognosis resulting from the first examination. In this connection, insistence should be made on the value of fluoroscopic examination, as conclusive information is thus obtained. If a radiographic tracing only had been taken, there is no doubt that it would have been found like Fig. 78, and that

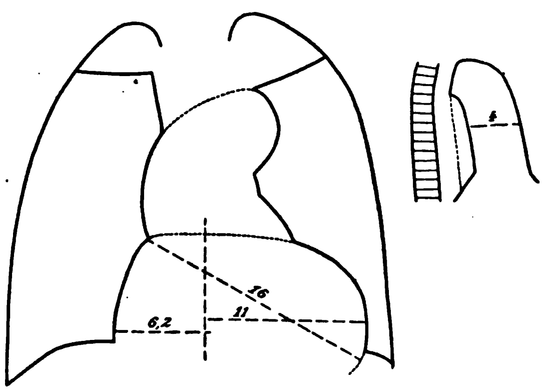

FIG. 79. AORTIC STENOSIS WITH AORTITIS. MAN 56 YEARS OF AGE

a serious lesion of the aorta would have been suspected which, in point of fact, did not exist.

On the other hand, when aortic stenosis is accompanied by aortitis affecting the thoracic aorta in its visible portion, a tracing is obtained analogous to that of Fig. 79, which leaves no room for doubt. This figure is of a man fifty-six years of age with aortic stenosis. The tracing shows hypertrophy of the two ventricles, especially of the

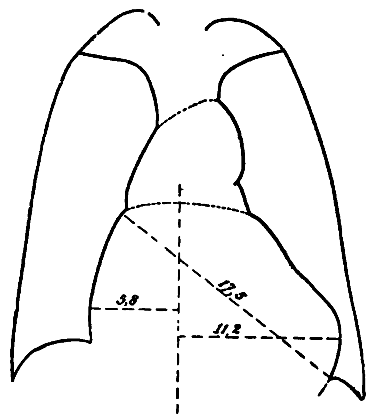

FIG. 80. DOUBLE AORTIC LESION. MAN 59 YEARS OF AGE

left, and in addition a uniform enlargement of the aortic shadow, in the frontal and oblique position. On the screen, this dark shadow shows no marked pulsations. The contrast between this case and the preceding gives information of practical value.

These indications, diagnostic of one or the other of the valvular lesions of the aorta, may be equally instructive in the diagnosis of associated lesions (Fig. 80). They permit of the determination of the signaletic state of the aorta which is, in this case, usually altered. They will be studied in more detail in one of the following chapters (see Aortitis, Chap. VIII).

CHAPTER V

CONGENITAL AFFECTIONS OF THE HEART

RADIOLOGY plays a more or less important part in the diagnosis of congenital lesions of the heart. This diagnosis is ordinarily easily made when it is a question of the most common lesion, that is, stenosis of the pulmonary artery with inter-ventricular perforation; it is on the contrary very difficult when it is a question of malformations which on auscultation and percussion give no sign or when they result from disturbances in the respective positions of the several cavities. Radiology does not attempt to remove all uncertainties, and it is true that it cannot demonstrate the persistence of patent ductus arteriosus, the transposition of the great vessels, etc.; but in demonstrating the modifications which certain malformations impress on the configuration of the heart, it allows at least suspicion as to the cause.

To complete the study which has just been undertaken, it is necessary to accumulate observations, to compare them with each other, and to draw conclusions which will facilitate further research. A report, therefore, of the cases examined and of the indications furnished by radiological examination will be given in the following chapters.

I. STENOSIS OF THE PULMONARY ARTERY WITH INTER-VENTRICULAR PERFORATION

This affection, the most frequent of the congenital lesions, is ordinarily revealed by cyanosis from birth, increasing progressively as time goes on, and accompanied by more or less pronounced dyspnœa. Palpation

gives a systolic thrill, in two areas, one at the origin of the pulmonary artery, the other at the median region of the heart. Auscultation gives a rough systolic murmur, in the second intercostal space, transmitted toward the left clavicle, and sometimes another murmur, also systolic, of deeper tone, heard at its maximum in the third intercostal space and transmitted transversely toward the axilla.

However, these signs are not constant and the interpretation of them is difficult, especially in inter-ventricular perforation associated with stenosis of the pulmonary artery, a communication most difficult to determine. In these cases radioscopic examination gives precise information, as the following show:

1. Mme. M., age twenty-five years, dyspnœa on exertion from early infancy. Dyspnœa has increased for several years and causes paroxysms which oblige the patient to go to bed for weeks and months at a time. No cyanosis evident. Examination of the eyes (Dupuy-Dutemps method) does not reveal retinal cyanosis; but the arteries are darker than normal. No œdema of the legs. No disturbance with elimination of chlorides. Blood examination: RC = 3,910,000; WC = 14,000.

On examination of the heart a slight systolic thrill is noticed in the second and the third left intercostal space transmitted transversally toward the axilla. Auscultation gives a murmur which is clearly systolic, rough in the second space, softer in the third and fourth spaces, transmitted toward the clavicle, the neck, the axilla, and sharply audible in the back between the left scapula and the vertebral column.

In this patient the clinical diagnosis of stenosis of the pulmonary artery with inter-ventricular perforation is obvious by the combination of functional symptoms and objective signs characteristic of the affection, notwithstanding the absence of congenital cyanosis.

The orthodiagraphic tracing in the frontal position

(Fig. 81) shows that the left contour presents nothing abnormal, that the apex of the heart rests on the diaphragm, from which it separates in deep inspiration. The right contour, more developed than in the normal state, overlaps considerably the medio-sternal shadow. On the lower part, corresponding to the right ventricle, may be noted ample pulsations of the cardiac shadow.

In general, however, the diameters of the heart are not exaggerated.

Longitudinal diameter	13 cm.
Horizontal	12.5 cm.
D'G	10 cm.

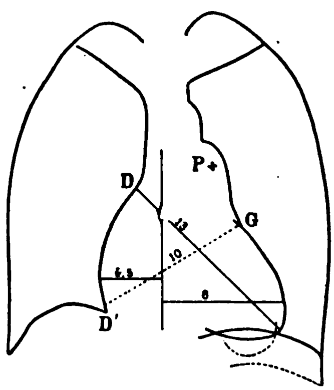

FIG. 81. MME. M., 25 YEARS OF AGE

PULMONARY STENOSIS AND INTER-VENTRICULAR PERFORATION

In this figure, however, an anomaly exists which is important to note: there is an exaggerated saliency of the median arc in the upper part at the level of the pulmonary artery shadow (P). The cross marked on this figure corresponds to the site of the murmur and of the purring thrill.

In the right posterior oblique position at 50 degrees

(Fig. 82), the outlines of the left auricle (OG) and of the left ventricle (VG) present nothing abnormal. On the contrary, in the retro-cardiac clear space downward under the aortic shadow (A), an exaggerated salience of the pulmonary artery (Pul) is seen.

In the right anterior oblique position at 50 degrees (Fig. 83), the shadow of the left ventricle is normal, but the salience of the pulmonary artery in the retro-sternal clear space is considerable. In the retro-cardiac clear space downward below the aortic shadow (A), an exaggerated projection of the pulmonary artery is seen (Pul), with an increase in the outline of the right auricle (OD) and with an enlargement of the right ventricular (VD) shadow.

The findings, therefore, in the three positions give similar information: the left ventricle is of normal dimensions; the right cavities, especially the ventricle, are enlarged; finally, the pulmonary artery in its entire visible portion is much dilated.

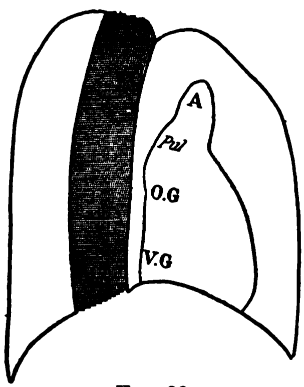

FIG. 82

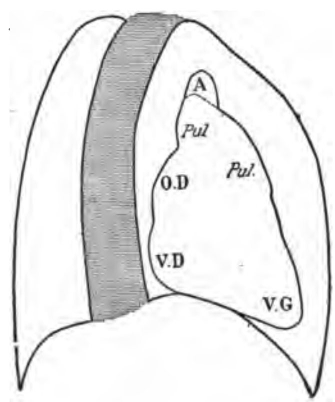

FIG. 83

FIG. 82. SAME PATIENT, IN RIGHT POSTERIOR OBLIQUE POSITION AT 50 DEGREES

A, aorta. *Pul,* pulmonary artery. OG, left auricle. VG, left ventricle.

FIG. 83. SAME PATIENT, IN RIGHT ANTERIOR OBLIQUE POSITION AT 50 DEGREES

2. Mlle. C., twenty-five years of age; since childhood subject to attacks of dyspnœa which had become almost incessant so that she had had to stop work four months previously. Moderate cyanosis of the face and the hands showing more when active; slight retinal cyanosis (Dupuy-Dutemps). Blood findings: RC = 4,200,000; WC = 14,000.

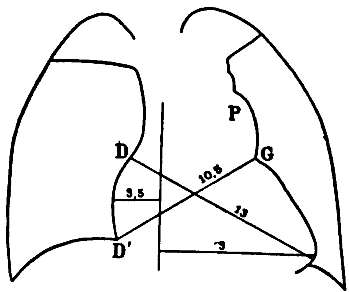

FIG. 84. MLLE. C., 25 YEARS OF AGE
PULMONARY STENOSIS AND INTER-VENTRICULAR PERFORATION

Examination of the heart gives a very intense purring thrill greatest at the level of the second left intercostal space; on auscultation, a rough systolic murmur is heard all over the precordial region, most marked at the level of the left second intercostal space and transmitted toward the clavicle and to the back. The clinical characteristics indicate stenosis of the pulmonary artery with interventricular perforation.

Orthodiagraphic examination presents, beside the general characteristics common to this lesion, some other changes. In the frontal position (Fig. 84), the usual enlargement of the pulmonary arc in its main portion is noticed. But especially is the increase of the cardiac shadow, both right and left ventricle, more marked here than in the preceding case. The shadow of the aorta disappears in the right posterior oblique position at an angle

of 40 degrees instead of 30, the normal figure. The measurement of the diameters is:

Longitudinal diameter	13 cm.
Horizontal	12.5 cm.
D'G	10.5 cm.

In the oblique positions (OPD and OPG, Figs. 85 and 86) examination shows that the right auricle is especially enlarged. Finally, a slight dilatation of the right ventricle was observed on exertion. The result was that if these signs confirmed the diagnosis, they demonstrated also that the heart by reason of its enlargement and increase of the right cavities was beginning to show signs of failure of compensation.

3. Mlle. Mo., twenty-three years of age, presents also subjective and objective signs characteristic of congenital lesion of the pulmonary artery.

Examination of the tracing (Fig. 87) shows that the pulmonary arc or the median arc is considerably developed, which is evidence of dilatation of the pulmonary artery to a very marked degree. On the other hand, the contour of the left ventricle is strongly accentuated, the

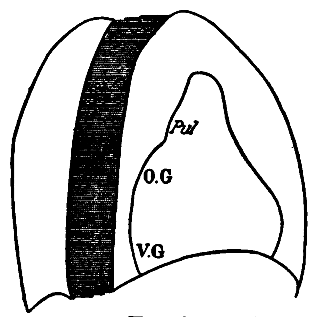

FIG. 85

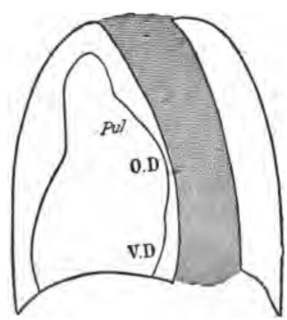

FIG. 86

FIG. 85. SAME PATIENT AS FIG. 84, IN RIGHT POSTERIOR OBLIQUE POSITION AT 50 DEGREES

FIG. 86. SAME PATIENT, IN LEFT POSTERIOR OBLIQUE POSITION AT 50 DEGREES

right contour itself is exaggerated and all the diameters are increased: the longitudinal diameter and the horizontal measure 15 cm.; the line D′G, 12.6 cm. The apex of the heart, pushed sharply outward and slightly lowered, disappears in the right posterior oblique position at an angle of 50 degrees. The conclusion is then that the effect of the lesion on the heart is much more manifest than in the preceding cases.

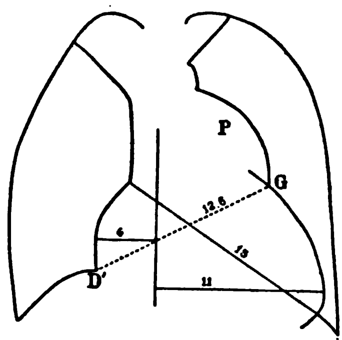

Fig. 87. MLLE. MO., 23 YEARS OF AGE
PULMONARY STENOSIS AND INTER-VENTRICULAR PERFORATION

4. The modifications just indicated are not peculiar to old lesions, and are found in very young children, as demonstrated by the orthodiagram shown in Fig. 88, which

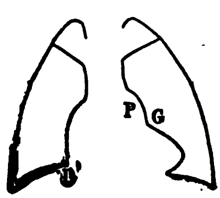

Fig. 88. CHILD 17 MONTHS OLD
PULMONARY STENOSIS AND INTER-VENTRICULAR PERFORATION

is of a child seventeen months old with congenital cyanosis, presenting signs ordinarily characteristic of stenosis of the pulmonary artery, accompanied by inter-ventricular perforation. In a general way, it recalls the other tracings. The heart is pushed outward, the development of the right cavities is exaggerated and the pulmonary arc makes an abnormal salience.

The radiological data in the case of stenosis of the pulmonary artery with inter-ventricular perforation may be summed up as follows:

(a) Exaggerated development of the shadow of the right ventricle and often of the right auricle.

(b) No increase, or slight increase at the beginning, of the contour of the left ventricle; more considerable increase in a later phase of the disease.

(c) Exaggeration of the median arc or the pulmonary arc, especially in its superior portion.

The first two findings agree with the pathology. Both methods of examination demonstrate that the right ventricle becomes progressively hypertrophied in order to overcome the resistance offered to the blood stream by the contraction of the pulmonary orifice, and that in the end the circulatory difficulties fall upon the right auricle. Though the left auricle shows no notable changes in the beginning, later, however, it becomes hypertrophied, especially when functional disturbances are marked.

Dilatation of the pulmonary artery would not seem, according to anatomical evidence, to constitute a constant symptom of this disease, though it has been noted in several cases. But radioscopic examinations showed that it was never lacking. The necessary conclusion from this is that in life the artery is much distended, but that this distension rarely results in a permanent dilatation, so that after death very little evidence is found and only in a very inconstant manner. Later this interesting question will be dealt with again.

II. SIMPLE STENOSIS OF THE PULMONARY ARTERY

Stenosis of the pulmonary artery is characterized solely by a systolic murmur at the base, intense, vibrant, sometimes rasping, heard in the left second intercostal space and accompanied, on palpation, by a purring thrill. It is transmitted up toward the left clavicle, but is absent in certain cases, notably when stenosis affects the vessel to a sufficiently great extent.

On percussion, the transverse dullness of the heart is increased and overlaps the right contour of the sternum, which indicates a more or less marked hypertrophy of the right cavities.

As to functional signs, they are extremely variable. If dyspnœa is frequent with palpitations supervening even during rest, cyanosis, on the contrary, is very inconstant and may even be absolutely lacking.

Three observations of this affection are presented here:

1. Child fourteen years of age with intense cyanosis and considerable dyspnœa with paroxysmal attacks. Localized purring thrill at the left second intercostal space, no clear murmur heard.

The orthodiagraphic tracing of this patient (Fig. 89) presents the characteristic form known as *"en sabot"*: the heart apex is pushed outward and elevated; below it

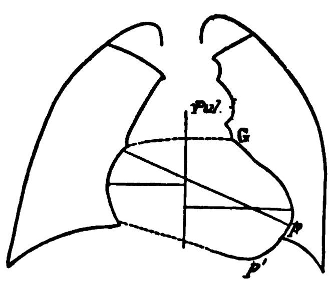

FIG. 89. PULMONARY STENOSIS

p, apex of the left heart; *p'*, apex of the right heart. (Heart *"en sabot."*)

the apex of the right ventricle is rounded and the inferior contour of the heart descends much lower than normally. The right contour greatly overlaps the sternum. In the vicinity of the diaphragm very ample systolic pulsations of the hypertrophied right ventricle are seen. Finally, the left median arc or pulmonary arc shows an abnormal salience in its upper part.

2. Nina P., twenty-three years of age, with Friedreich's disease (case reported by Babinski), gives a very localized murmur in the left second intercostal space, transmitted toward the clavicle. Slight tremor attacks of paroxysmal tachycardia with syncope. Slight cyanosis.

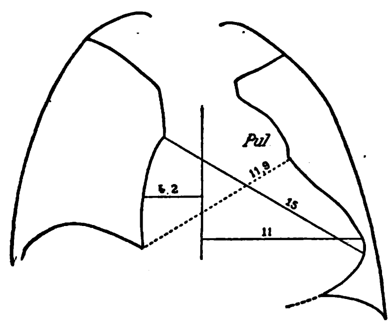

FIG. 90. NINA P., 23 YEARS OF AGE
CONGENITAL PULMONARY STENOSIS

The orthodiagraphic tracing of this patient (Fig. 90) presents the same characteristics as the preceding, but with the following differences: a greater development of the heart, apex of the left ventricle elevated and pushed outward, lower contour of the right ventricle exaggerated and displacement of the right cavities toward the right. The diameters are:

Longitudinal diameter	15.4 cm.
Horizontal	15.2 cm.
D'G	11.9 cm.

Finally, the median arc or the pulmonary arc makes a considerable salience.

3. Mlle. Mu., twenty years of age; systolic murmur heard in the second left intercostal space, purring thrill, dyspnœa.

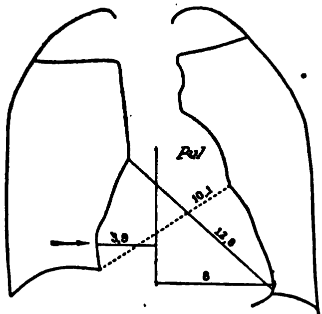

FIG. 91. MLLE. MU., 20 YEARS OF AGE
CONGENITAL PULMONARY STENOSIS

Here the orthodiagraphic characteristics (Fig. 91) are less definite than in the first two tracings. The volume of the organ is nevertheless exaggerated. The apex of the heart is pushed slightly outward but is not elevated. The contour of the left ventricle which appears rather large does not, however, indicate that the cavity is increased. The salience of the left ventricle, in fact, is not abnormal in the right posterior oblique position. Hypertrophy of the right ventricle is evident exclusively by its sharp projection to the right and by the pulsations (at the level of the arrow).

The diameters are:

Longitudinal diameter	12.8 cm.
Horizontal	11.9 cm.
D′G	10.1 cm.

The median arc or the pulmonary arc is manifestly exaggerated.

It will be seen that in the case of simple stenosis of the pulmonary artery, the essential data obtained by radiological methods consist: (1) in the enlargement of the right ventricle; (2) in an abnormal salience of the pulmonary arc, a salience which can be determined, at least, in the majority of cases; (3) in the absence of apparent modifications in the volume of the left ventricle.

The enlargement of the right ventricle is a constant fact; besides, pathological anatomy demonstrates that it is seldom lacking. It is not due to a dilatation of the cavity, but to a real hypertrophy of the wall described by Moussous[20] as follows: "The ventricular cavity is not very voluminous, it contains less fluid than it ought to contain, and its walls are extremely thick. The *columnae carneae* are strongly marked as well as the papillary muscles. The muscular development assumes an unusual importance. Sometimes the thickness of the walls is due to a slight sclerosis; there is diffuse or localized myocarditis. Histological studies on this subject, however, are very scant. The results of some microscopic examinations justify the statement that hypertrophy properly so called is the principal fact."

As for the dilatation of the pulmonary artery, observed in all the cases which we have studied, and which is not considered as persisting after death, that may be explained in different ways: in the first place it can be admitted that when stenosis, instead of being limited to the orifice, affects to a great extent the vessel, there is no dilatation. We have observed a case of this type. In others it is fair to suppose that the dilatation must have been of functional origin and for that reason was not found on autopsy.

The absence of modifications in volume of the left ventricle is easily understood, for this cavity is not in any way concerned in the lesion which affects only the right heart.

[20] Moussous, *Maladies congénitales du cœur. Collection Léauté.*

III. INTER-VENTRICULAR PERFORATION

This condition, which has been described by Roger,[21] is accompanied by a systolic purring thrill at the level of the third left intercostal space, a thrill which is apparently lacking when the patient is on his back, but which almost always reappears in left lateral recumbency. Auscultation gives a systolic murmur, unchanging, rough, intense, high pitched, at its maximum heard in the inner part of the third intercostal space and the fourth rib, and which is transmitted outward but diminishes rapidly.

On percussion there is an increase in the transverse dullness of the heart. There are generally no functional signs, but less constantly than Roger thinks, for in a certain number of cases dyspnœa and cyanosis are found, less marked, it is true, than in the preceding cases, and always occurring later. Observations of such cases are presented here:

1. Mlle. V., ten and one-half years of age, height 1.51 m., weight 25 kilograms; apparent health entirely normal. No dyspnœa, patient can run without the least discomfort; there is no trace of cyanosis. Auscultation gives an intense systolic purring thrill, especially in left lateral recumbency at the level of the third intercostal space, transmitted outward but not to the axilla.

Radioscopic examination shows a heart of considerable volume and abnormal in form (Fig. 92). The right and left contour are markedly developed on both sides of the medio-sternal line. Synchronous systolic pulsations are visible in both contours.

The diameters are:

Longitudinal diameter	13.9 cm.
Horizontal	14.6 cm.

The apex of the heart, markedly globular, is pushed outward and elevated; the contour of the right ventricle is rounded below the diaphragm during inspiration and

21 Roger, *Académie de Médecine*, 1879.

projects markedly to the right. The right ventricle shows a marked hypertrophic dilatation; the left ventricle is also increased in volume.

The vascular arcs show no exaggeration.

2. Mme. Sch., forty years of age. Subject since infancy to attacks of dyspnœa. For some time these attacks have become very severe and frequent, accompanied by palpitation, pain at the level of the second left intercostal space, and extra-systolic arhythmia. No cyanosis. The general state of health has been, nevertheless, fairly satisfactory. Six confinements. Three children died in infancy.

Examination of the heart shows an intense systolic thrill, localized in the third left intercostal space and limited to this space. Cardiac dull area slightly enlarged, overlapping the sternum at the base.

On auscultation, there is heard over the entire precordial region a systolic murmur, rough, rasping, high pitched, at its maximum in the third left intercostal space, near the sternum and transmitted transversally toward the left; it is not heard under the clavicle.

Fig. 93, an orthodiagraphic tracing, shows a cardiac

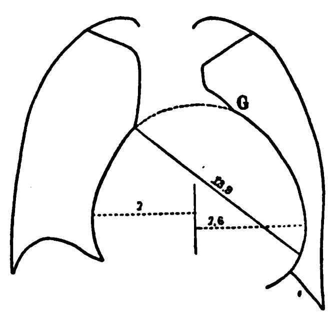

FIG. 92. MLLE. V., 10½ YEARS OF AGE
INTER-VENTRICULAR PERFORATION

Very large globular heart, median, equally enlarged right and left; ample systolic pulsations on both sides.

area markedly developed on both sides of the mediosternal line, left contour elongated, convex, rounded apex descending below the diaphragm and level with it in deep inspiration; the right contour projects broadly, especially in its upper portion (auricular). At the level of the arrow are seen ample systolic pulsations of the hypertrophied right ventricle.

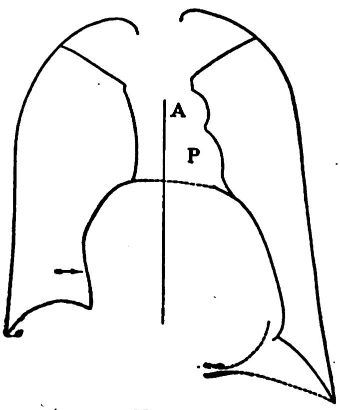

FIG. 93

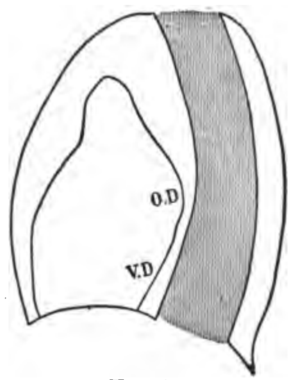

FIG. 94

FIG. 93. MME. SCH., 40 YEARS OF AGE
INTER-VENTRICULAR PERFORATION

A, aorta; P, pulmonary artery.

FIG. 94. SAME PATIENT, IN LEFT POSTERIOR OBLIQUE POSITION AT 62 DEGREES

The vascular arcs are moderately accentuated and pulsate very actively. The aorta and the pulmonary artery do not appear dilated.

In the left posterior oblique position the clear space appears, much reduced, at an angle of 62 degrees. The outline of the heart indicates an enlargement both of the right auricle and of the right ventricle (Fig. 94).

In the right posterior oblique position, the apex of the heart disappears at the slightly wide angle of 35 degrees.

In another case, on account of the existence of a systolic murmur heard entirely in the central region of the heart, a diagnosis of inter-ventricular perforation without stenosis of the pulmonary artery was affirmed by radioscopic examination with certain reservations. This tracing (Fig. 95), in fact, shows that the heart is markedly developed on both sides of the medio-sternal line, as in the preceding cases, and that the hypertrophy of the right ventricle is greater than that of the left ventricle; but, on the other hand, an enlargement of the left median arc is observed indicating a slight dilatation of the vessel. The patient was also slightly cyanotic. Therefore after having affirmed clinically the absence of stenosis of the pulmonary artery, finally, on radioscopic examination, an opinion was given that alteration of the pulmonary artery was present.

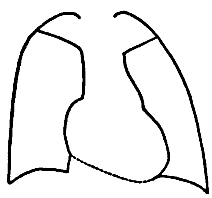

FIG. 95. ALBERT D., 33 MONTHS OF AGE
POSITIVE INTER-VENTRICULAR PERFORATION

Pulmonary stenosis probable because of the marked salience of the median arc.

Besides these cases, in which the radiological aspect of the heart has very definite characteristics, patients are found affected with Roger's disease, in whom orthodiagraphic examination demonstrates only a slight influence of the lesion on the volume of the heart. The slight hypertrophy of the two ventricles can be shown as follows: convex left contour; apex pushed outward, slightly elevated and globular; inferior contour of the right heart lowered; right outline overlapping the pulmonary field to some extent; horizontal diameter slightly greater than

the longitudinal. Finally, as in other observations, no changes in the vascular arcs. The cardiogram (Fig. 96) represents this aspect of the heart.

It is to be noted also that the importance of the changes is not always in relation to that of the lesions. The exterior configuration, however, conforms in all respects to the anatomical changes of the septum which has been described.

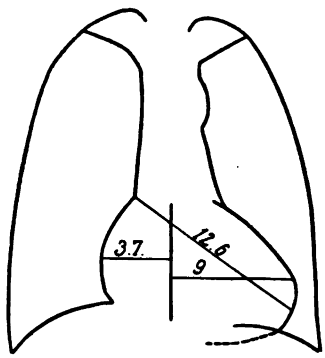

FIG. 96. DEL., 32 YEARS OF AGE
INTER-VENTRICULAR PERFORATION

To summarize, therefore, the findings in Roger's disease, the radioscopic characteristics are as follows:

1. The cardiac shadow usually shows an increase as a whole and is developed equally on both sides of the mediosternal line; however, hypertrophy of the right ventricle is more important than that of the left ventricle. In some less characteristic cases, the increase in volume of the heart is not so marked and the outlines are scarcely deformed. Nevertheless, the usual signs of hypertrophy of the two ventricles are found.

2. Clear, full pulsations of the left and right contour may be demonstrated.

3. There is no change in the vascular arcs.

In a general way these data confirm the pathological

findings which show that cardiac hypertrophy chiefly affects the right ventricle. However, Merklen has declared that there is in addition a rather marked dilatation of the pulmonary artery, as in the cases in which there is stenosis of the orifice. The last observation would seem to confirm this statement of Merklen, but it may be pointed out that this observation has not seemed convincing and that on this point some reservations had to be made relative to the possible coexistence with interventricular perforation of a lesion of the pulmonary artery. Perhaps the same was true in the cases observed by Merklen.

IV. CONGENITAL AORTIC STENOSIS

Congenital stenosis of the aorta presents in a general way the same objective signs as acquired aortic stenosis: purring thrill more or less marked at the area of the orifice, systolic murmur transmitted toward the right clavicle, marked enlargement of the left ventricle. The functional signs consist in the early appearance of palpitation, of dyspnœa on exertion, etc.

In a case which was examined, radiological investigation confirmed the diagnosis, and determined an interesting detail, the significance of which already has been discussed when congenital stenosis of the pulmonary artery was considered, namely, dilatation of the vessel below the lesion.

Carmen P., thirteen years of age, sickly and emaciated, of keen intelligence, but constrained to relative immobility, the least movement causing attacks of palpitation and dyspnœa. These disturbances appeared as soon as the child began to walk. Examination of the chest shows the existence of forcible impulsive pulsations in the aortic region. The pulsations of the aorta, perceptible in the sternal notch, are accompanied by an intense thrill.

The orthodiagraphic tracing (Fig. 97) shows the left contour of the heart convex and elongated; the apex is

rounded, depressed, pushed slightly outward. The right contour is not modified; only the left ventricle is hypertrophied.

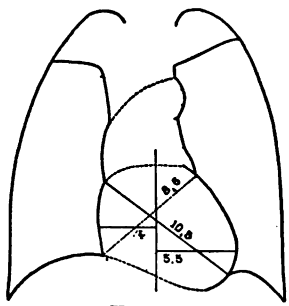

FIG. 97

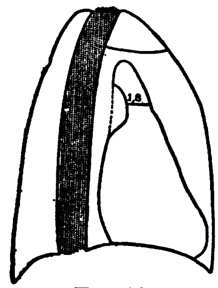

FIG. 98

FIG. 97. CARMEN P., 13 YEARS OF AGE

CONGENITAL AORTIC STENOSIS. Hypertrophy of the left ventricle, dilatation of the aorta.

FIG. 98. SAME PATIENT, IN RIGHT ANTERIOR OBLIQUE POSITION

Diameter of the ascending aorta: 1.8 cm.

The diameters are:

Longitudinal diameter	10.5 cm.
Horizontal	9.5 cm.
D′G	8.6 cm.

The right median arc and the left superior arc are exaggerated, and in the frontal position this corresponds to an enlargement of the aortic arch. In the right anterior oblique position (Fig. 98), the shadow of the ascending aorta is enlarged. The volumetric description of the aorta[22] by the method of the three dimensions gives the following results:

Transverse diameter	5.5 cm.
Chord	2.0 cm.
Descending aorta	1.8 cm.

22 See below (Aortitis) the study of the volume of the aorta by the three dimensions method.

The caliber of the vessel is about 2 cm., a figure that is high for a girl thirteen years of age. Finally, rather ample pulsations along the aortic walls are noted.

The pulmonary artery is not dilated, the left median arc is normal; pulsations here were marked and more ample than those of the aorta.

The result of this observation is that aortic stenosis is characterized from the radiological point of view by hypertrophy of the left ventricle and dilatation of the aorta.

Ventricular hypertrophy is easily understood and agrees with the pathological findings. As for the dilatation of the aorta, it is a matter for discussion, because not ordinarily found in autopsies. It is very probable that it is to be explained in the same way as dilatation of the pulmonary artery, in case of congenital stenosis of the orifice, and that it is due to a distension of functional nature, so that it may be perceptible during life but not found after death, though it has been noted.

The congenital origin of aortic stenosis, therefore, may be suspected in a young patient affected with this lesion whenever radioscopy shows more or less marked dilatation of the vessel.[23]

V. CARDIAC ECTOPIA AND TOTAL INVERSION OF THE VISCERA

We have twice observed this malformation, which is, moreover, only of documentary interest. In the first case, the patient was affected with cardiac ectopia following congenital sternal malformation. Union had not taken place in the lower three-quarters of the body of

[23] We have had occasion to observe other cases of congenital stenosis of the aorta in children. The radiological characteristics agreed absolutely with those which we have just presented. We found the dilatation of the vessel above the lesion, such as described. On the screen, the aorta showed very ample pulsations.

the sternum with separation of the xiphoid appendage. A hernia of the heart resulted.

Other malformations were also noted: inter-ventricular perforation, double superior vena cava, etc. The heart was very voluminous, especially because of the hypertrophy and the dilatation of the right cavities, auricle and ventricle. The aorta was small, the pulmonary artery very much dilated. These findings naturally could not have been obtained until after death, and diagnosis of the ectopia alone was made during life.

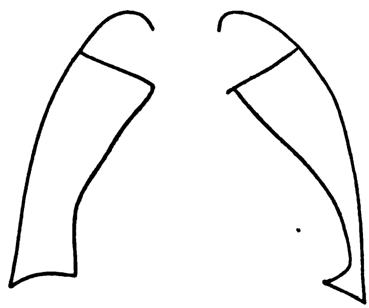

FIG. 99. CARDIAC ECTOPIA

Inter-ventricular perforation. Marked hypertrophy of the right ventricle.

Radioscopic examination gave only a very incomplete image of these multiple malformations. In the frontal position (Fig. 99), a very marked development of the cardiac shadow, right and left of the median axis, was noted. In the left posterior oblique position at 50 degrees (Fig. 100), at P and at P′ two centers of superimposed pulsations were observed, which gave the impression of two apices of the heart. In fact, it was the apex of the left ventricle which pulsated at P and the lower edge of the right ventricle at P′. These exceptional observations may be made use of by observers in analogous cases.

The second case was a question of dextrocardia with total inversion of the organs. Radioscopy confirmed the

displacement of the heart and showed that it was not due solely to a torsion of the organ at the base, nor to cardiac fixation caused by old adhesions; in short, it was not an acquired dextrocardia. All the relations of the inverted heart with the neighboring organs were normal. Radioscopy also demonstrated the inversion of the other organs, which is the rule in congenital dextrocardia.

Figure 101, which shows this anomaly, is taken in the frontal or direct anterior position; it looks like an orthodiagram taken in the dorsal position. The apex of the heart is on the patient's right, the ascending aorta on the left, the arch goes from left to right, the stomach is on the right, the liver is on the left. The patient was sixty-two years of age and has been able to lead a normal existence up to the present time.

These cases of congenital conditions are the only ones that conclusions can be drawn from. According to cer-

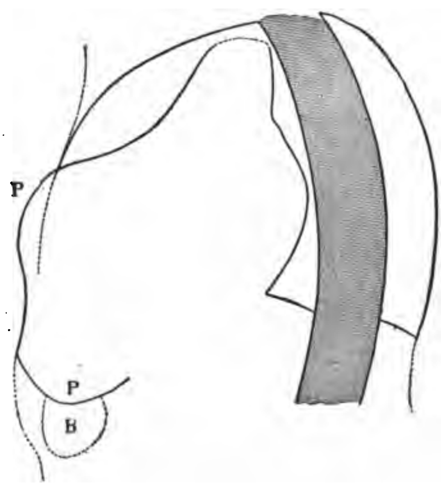

FIG. 100. CARDIAC ECTOPIA SEEN IN THE LEFT POSTERIOR OBLIQUE POSITION AT 50 DEGREES

P, apex of the left ventricle; P′, apex of the right ventricle; B, gastric air-bubble.

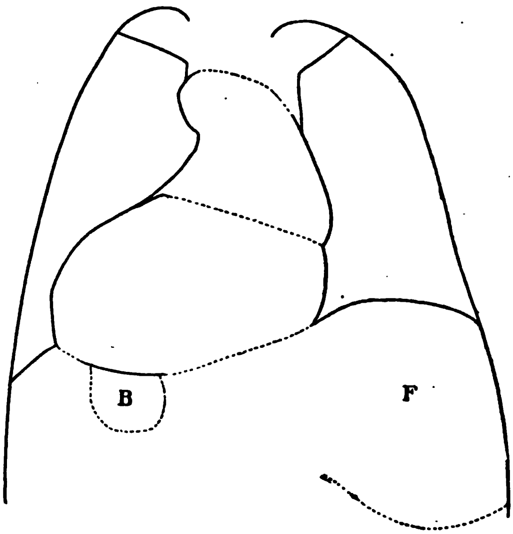

FIG. 101. INVERSION OF THE ORGANS

B, gastric air-bubble; F, liver.

tain writers, notably Groedel,[24] Anheim, Hoffmann,[25] the persistence of Botal's duct (ductus arteriosus) could be equally well shown by the particular aspect of the heart on radioscopic examination. According to them, the heart with this lesion would keep its normal dimensions, but a very special enlargement of the median arc would exist, which corresponds, as is known, to the region of the pulmonary artery, of the auricula and the left auricle. Enlargement of the upper part would indicate simply that there is a dilatation of the pulmonary artery, whereas a simultaneous enlargement of the inferior part which corresponds to the left auricle would favor the persistence of Botal's duct. We have not had occasion to verify this fact.

[24] Th. et Fr. Groedel, *Sur la forme de la silhouette du cœur dans les affections cardiaques congénitales.* Deutsches Arch. f. Klin. Mediz. B. CIII, 13, juillet, 1911.

[25] Hoffmann, *L'examen fonctionnel du cœur,* 1911.

Up to the present time the persistence of the ductus arteriosus has not been the subject of conclusive clinical evidence. In one case where it was suspected, it existed, with the usual signs on auscultation, a dilatation affecting at the same time the aorta and the pulmonary artery. These data and de la Camp's observations of the abnormal force of the pulmonary artery pulsations have only a documentary value.

The study of the radiological findings just discussed in the diagnosis of congenital lesions of the heart shows the importance of the information furnished radiologically in cases which were suspected because of functional and physical signs but could be affirmed only with certain reservations.

Besides these cases there are others where it is impossible to specify the nature of the cardiac changes, the existence of which is evident as cases of progressive congenital cyanosis, accompanied by more or less acute dyspnœa, etc., in which by auscultation or percussion no diagram of the configuration of the heart and of the lesions can be even approximately established. It is true that these signs may be considerable, and it is known that some cases with extensive stenosis of the pulmonary artery and others with wide inter-ventricular openings may not give any auscultatory signs. In some of these cases, however, radiology demonstrates sufficiently so that an almost positive diagnosis from the outline of the heart and its vessels can be made. Some of the most convincing cases are given here:

Recently one of us with Laubry reported to the *Société médicale des hôpitaux*[26] a case of a patient twenty-seven years of age, since infancy affected with progressive cyanosis accompanied by polycythemia (seven million

[26] Laubry et Bordet, *Un cas de cyanose congénitale. Signs pérephériques marques, signes stéthoscopiques légers. Netteté de l'examen orthodiagraphique.* Soc. méd. des hôpitaux, 13 octobre, 1911.

red corpuscles). On auscultation no abnormal sound was heard except a slight galloping rhythm on the right and a metallic hardness of the secondary sound at the pulmonary area. In the frontal position (Fig. 102), the orthodiagram showed a considerable increase of the area of cardiac projection, also a marked projection of the right ventricle; the amplitude of the pulsations was marked to the right of the sternum. The contour of the ventricle descended below the line of the diaphragm and the apex of the heart was elevated.

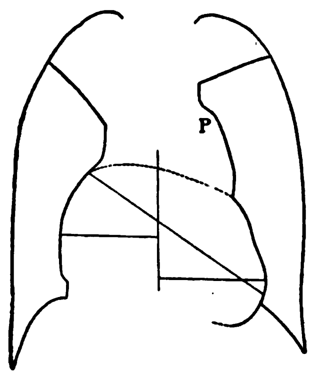

FIG. 102. MLLE. B., CONGENITAL CYANOSIS

There was therefore a marked concentric hypertrophy of the right ventricle. The left ventricle was normal. Finally, the left median arc showed a marked enlargement in its superior portion, which indicated a dilatation of the pulmonary artery.

In the right posterior oblique position (Fig. 103), the left auricle appeared to be normal, whereas in the left posterior oblique position (Fig. 104), the contours of the right auricle and ventricle formed an exaggerated salience. The combination of these signs warranted the conclusion that a pulmonary stenosis existed, situated possibly at the level of the valves, but also extending to a considerable portion of the superadjacent artery.

At the beginning of this chapter it was stated that radioscopy applied to the study of congenital lesions of the heart allowed not only a final diagnosis to be made that had been doubtful or even impossible, but that the evolution of the lesion could be prejudged by the nature of the evidence which it could furnish, either after a single examination or after a series of examinations. By referring to the history of Mlle. C., this point is brought out. (See observation No. 2.) Case of stenosis of the pulmonary artery with inter-ventricular perforation (Figs. 84, 85, 86). In this case examination of the orthodiagraphic tracings (Fig. 105) taken before and after physical activity such as walking quickly and lowering and raising the body several times in succession, showed a very sharp variation in the two diameters of the heart. Whereas before and after physical exertion, the longitudinal diameter did not vary, the horizontal diameter increased from 11.4 cm. to 11.8 cm., while diameter D′G increased from 10.5 cm. to 11.2 cm. This difference could

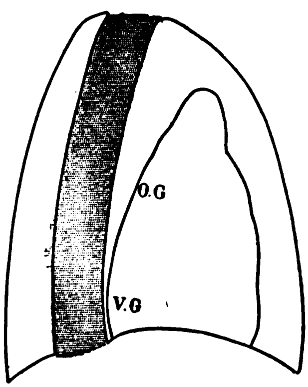

Fig. 103

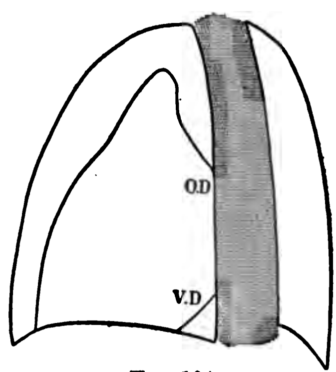

Fig. 104

Fig. 103. SAME CASE, IN RIGHT POSTERIOR OBLIQUE POSITION
No exaggerated salience of the left auricle (OG).

Fig. 104. SAME CASE, IN LEFT POSTERIOR OBLIQUE POSITION
Exaggerated salience of the right auricle and ventricle.

be explained only by the enlargement of the right inferior arc of the heart, which had a direct relation to the dilatation of the right ventricle. Radioscopy allows, therefore, the opportunity to obtain, at the outset, the first signs of cardiac failure which later developments confirm.

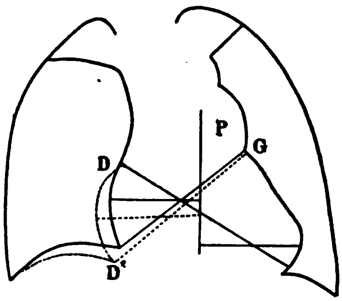

FIG. 105. MLLE. C., PULMONARY STENOSIS WITH INTER-VENTRICULAR PERFORATION

Dotted line shows the right contour of the heart after physical exertion.

CHAPTER VI

RADIOLOGICAL OUTLINE OF THE HEART IN CERTAIN PATHOLOGICAL CONDITIONS NOT RESULTING FROM VALVULAR LESIONS

I. CARDIAC HYPERTROPHY AND DILATATION

CARDIAC hypertrophy is not due exclusively to valvular lesions. It may be due to other causes, the most frequent of which, according to many writers, is Bright's disease. The question arises as to whether it is the direct result of sclerosis of the kidney, as Potain believes. This is probably not so and it is necessary rather to agree with Traube's opinion that it results from the arterial hypertension which accompanies this disease. The evidence of this is that it appears in patients with hypertension before there is any renal lesion. It constitutes, therefore, a defensive reaction against circulatory disturbances, whereas dilatation indicates that the resistance of the heart has begun to fail. The interest there is in knowing the degree and nature of the enlargement of the heart in patients with arterial hypertension is evident; it is here a question of prognosis which radioscopy is better able to make than any other method of investigation, as the following cases show, some in which arterial hypertension and cardiac hypertrophy constituted the only pathological signs, others in which they were complicated with confirmed Bright's disease.

Cardiogram 106 is of a man fifty years of age who suffered from painful precordial attacks with irradiations to the left arm, especially when exercising. The

only abnormal sign was had on auscultation, which gave an accentuation of the second aortic sound. Arterial tension was very high, being 22 cm. on the sphygmograph.

Radioscopy showed that the aorta was not affected, but that the left ventricle was enlarged. In Fig. 106, the aortic outline is much elongated, the apex of the heart is pushed outward and rounded, and the longitudinal diameter is considerably increased.

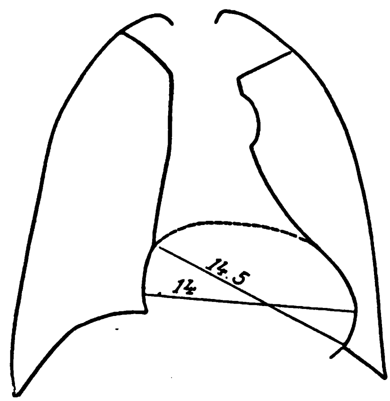

FIG. 106. HYPERTROPHY OF THE LEFT VENTRICLE
Hypertension. Man 50 years of age.

Fig. 107 gives analogous information in a patient whose clinical symptoms closely resemble those of the preceding case: attacks of angina, arterial hypertension as high as 27 cm., etc. But here the radioscopic signs were much more accentuated; the left contour of the heart was markedly developed, the apex was pushed outward and lowered; the longitudinal diameter measured 19 cm., the horizontal diameter, 17 cm. Moreover, the aorta was dilated and elongated. On the screen it was particularly dense.

The radioscopic signs are still clearer when arterial hypertension is accompanied by chronic interstitial nephritis.

Figs. 108 and 109 are two typical cardiograms of *renal*

heart. The form of the left contour seen here is markedly convex in its upper third, so that the line which marks this contour takes from point G an external direction with superior convexity. The apex of the heart is rounded, globular, and pushed somewhat outward. Point G is elevated and lies higher than point D. In short, left

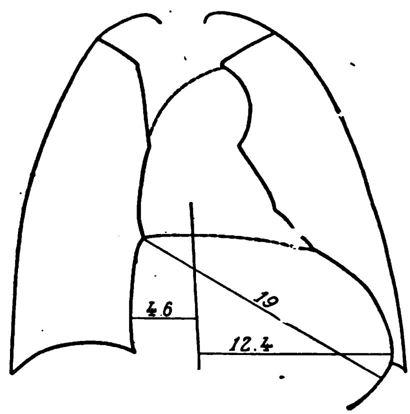

FIG. 107. MARKED HYPERTROPHY OF THE LEFT VENTRICLE
Very high tension. Man 56 years of age.

ventricular hypertrophy affects especially the base and the middle third of the cavity wall, for though all the diameters of the heart are increased, it is especially the diameter D′G which shows the most apparent increase.

Besides hypertrophy of the left heart, sometimes considerable hypertrophy of the right heart occurs in patients who have hitherto shown no cardiac manifestation. Lutembacher[27] has described a terminal tricuspid syndrome which appeared in the course of fibrous emphysematous lesions of the lung, of chronic bronchitis, and of fibrous tuberculosis. This syndrome is characteristic

[27] Lutembacher, *Syndrome tricuspidien terminal dans les lésions chroniques du poumon.* Archives des maladies du cœur, des vaisseaux, et du sang, avril, 1916.

of a cardiac insufficiency which rapidly becomes chronic. Early diagnosis of this complication therefore is of great importance. Radioscopic examination gives early evidence of cardiac failure when there is still time to give proper treatment.

The radiological image of the heart is *"en sabot."* The right ventricle is very large, rounded, occupies the

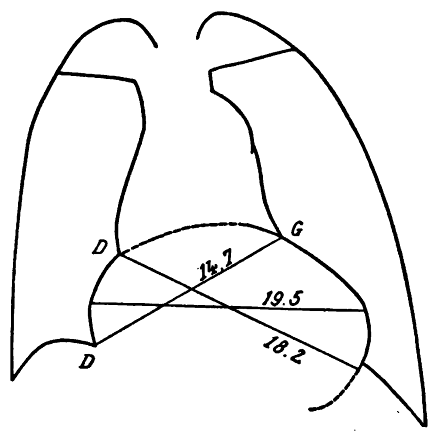

FIG. 108. RENAL HEART. MAN 57 YEARS OF AGE

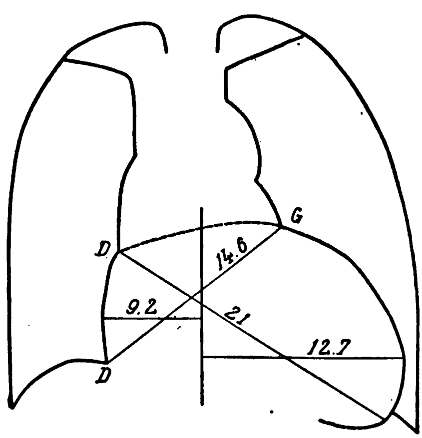

FIG. 109. LARGE RENAL HEART. MAN 50 YEARS OF AGE

whole anterior surface of the heart and pushes the apex upward and outward, thus showing the lower extremity of the right ventricle, which is normally obscured by the shadow of the diaphragm. The left outline of the heart, oblique from above downward and from within outward, corresponds, in its upper half, to the left ventricle, and in the lower half, convex from without inward, to the right ventricle. Moreover, an exaggeration of the upper part of the median arc, corresponding to a dilatation of the pulmonary artery is often noted, due, apparently, to the high tension of the smaller blood-vessels.

The heart, in this type of tricuspid insufficiency, is like that in stenosis of the pulmonary artery. Its outline is clearly differentiated from that observed in cases of functional tricuspid insufficiency, in which the heart is enlarged in its transverse diameter as a result of dilatation which affects principally the right auricle and in which the right ventricle is much less affected.

Finally, when hypertension exists of the larger and smaller blood-vessels in bronchitic emphysematous patients, radioscopy shows the "round heart" due to associated hypertrophy of the right and left ventricle. All these points are confirmed by autopsy. Clinically we find the signs of right and left ventricular cardiac insufficiency.[28]

II. CARDIAC HYPERTROPHY OCCURRING IN THE AGED

In old people enlargement of the heart may be due exclusively to a moderate but diffuse sclerosis of the arterial system which causes special deformations which it is necessary to recognize clearly.

The *senile heart* ordinarily shows the peculiar characteristics observable in Figs. 110 and 111. The left contour is convex in the upper third, the apex is globular, pushed outward; the heart rests on the diaphragm, which gives the radioscopic image a special configuration.

[28]Lutembacher, *loc. cit.*, p. 30.

The appearance of the aortic shadow which in a sense caps the heart, gives it the form of a "Phrygian bonnet." The artery itself is slightly dilated, dense and elongated; at its point of origin it encroaches on the right pulmonary field and its arc points decidedly outward under the left clavicle.

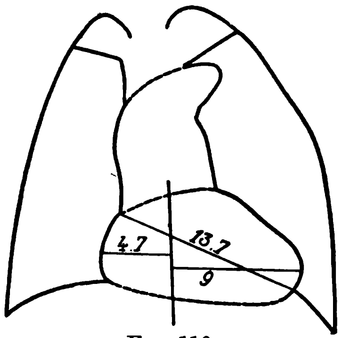

FIG. 110

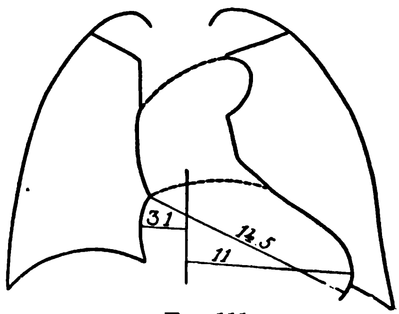

FIG. 111

FIG. 110. SENILE HEART. WOMAN 64 YEARS OF AGE

FIG. 111. APPEARANCE OF SENILE HEART IN A RELATIVELY YOUNG MAN, 45 YEARS OF AGE

In the course of the examinations we have been struck by the fact that this appearance of the senile heart, so often found, is not, however, exclusively confined to old age. We have met it, though not often, in patients of middle age; but in such cases close observation has always shown at the same time the existence of pathological signs of cardiac debility, of vascular sclerosis indicating a real though not severe affection of the circulatory system. In such cases, prematurely old, radiological investigation has shown changes which might be suspected but the nature and distribution of which were not shown by other methods of examination.

Cases of this class warrant the statement that deformation of the heart in the old cannot be considered as simply physiological and analogous to those we have just de-

scribed. The causes have not been completely studied, but their effects are certainly due to a pathological condition.

III. CARDIAC DILATATION

It has frequently occurred, in the course of our studies, that examples of dilatation of the heart have been found affecting either the left or right ventricle, associated with hypertrophy of one or the other of these cavities. Usually these were cases threatened with cardiac insufficiency, and radioscopic examination only confirmed the clinical findings.

However, there are cases in which moderate dilatation of the heart is hardly perceptible by the ordinary methods of examination, but in which prognosis is of great importance and which calls for early therapeutic attention. These are cases with Bright's disease or patients with valvular lesions in whom only a slight murmur is found, dyspnœa slightly more accentuated than usual, without notable organic reaction. It is very important therefore to recognize such cardiac dilatation as soon as it appears in order that the required therapeutic measures be immediately adopted. Radioscopy is here the preferable method of determining the existence of cardiac dilatation, however slight it may be, when percussion and palpation fail. The information is of still more value if, after several radioscopic examinations have been made of the same patient without giving new indications, the cardiac shadow is suddenly seen to change and assume the particular configuration which is symptomatic of dilatation of one or the other of the cavities.

Still more interesting are the radioscopic findings in cases in which there is no valvular lesion and in which there has not previously been recognized a ventricular hypertrophy associated with some general circulatory disturbance, but where signs of cardiac failure are found of uncertain origin and degree.

Without recurring here to the question of functional insufficiency, which was treated in another chapter, it is well to recall that cardiac dilatation, when it reaches a certain stage, causes patency of the auriculo-ventricular orifice of the left as well as of the right side. Mitral insufficiency is not always caused by an infectious endocarditis. There are many cases in which it appears only as an epiphenomenon in the course of cardiac dilatation. In these circumstances the important thing to know is the precise degree of this dilatation, even more than the existence of a systolic murmur at the apex. Though auscultation enables a diagnosis of this murmur to be made, it is incapable of revealing the pathogenic conditions which have produced it. It is probable also that the evolution of the disease may give the impression that the murmur is of organic or functional origin; but if to this uncertain information the idea of a rapidly developed cardiac dilatation is added in a patient hitherto free from cardiac affection, then the study will be simplified. Radioscopy furnishes here information which aids in interpreting these disputed cases.

The following, for example (Fig. 112), is the ortho-

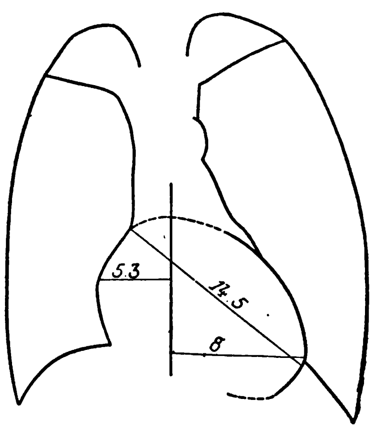

FIG. 112. ALCOHOLIC MYOCARDITIS. MAN 52 YEARS OF AGE

diagram of a man fifty-two years of age, free from cardiac disease in his youth, who for some months past has suffered from slight dyspnœa on exertion. For fifteen days the dyspnœa had been severe, continuous, and provoked by the slightest exertion; the face was cyanotic, the extremities slightly œdematous; the pulse was very rapid and feeble; the systolic pressure did not exceed 12 centimeters. It is evident that this was a case of rapidly progressive dilatation of the heart. Moreover, percussion showed that the right cavities overlapped by two finger-breadths the right edge of the sternum; the apex of the heart was lowered and pushed outward. On auscultation the sounds were dull, and there was a manifest irregularity of the pulsation probably associated with constant arhythmia. The history showed that the patient was markedly alcoholic and presented all the symptoms of it. In the region of the apex also a slight systolic murmur was heard, due to mitral insufficiency.

This case may be interpreted as being due to an organic insufficiency accompanied by acute dilatation of the cardiac cavities or it may be thought that this murmur was due only to a functional insufficiency related to alcoholic myocarditis. The clinical findings just described point to this second interpretation, but it is not a definite conclusion. On the other hand, radioscopic examination, by showing an enlargement of the heart in all its diameters, indicated that the heart was in a state of dilatation affecting the right and left cavities. Doubtless the murmur must have been related to a functional insufficiency, which had supervened in the course of an acute asystolia in a patient with alcoholic myocarditis, rather than to an old infectious endocarditis of which there is no trace.

If the dilatation is accompanied by a considerable hypertrophy of the right and left ventricular walls, the radiological appearance is that of a large globular heart, a typical aspect which allows of a diagnosis of myocarditis. Fig. 113 is an example. It is a man sixty-five years

of age with chronic myocarditis and aortitis. The two principal diameters of the organ are exactly the same length (18 centimeters); the contours of the two ventricles show an excessive but regular convexity; the apex of the heart is perfectly rounded. This patient died of cardiac insufficiency, and the anatomical evidence was then compared with the orthodiagraphic tracing; this tracing demonstrated exactly the globular development of the organ.

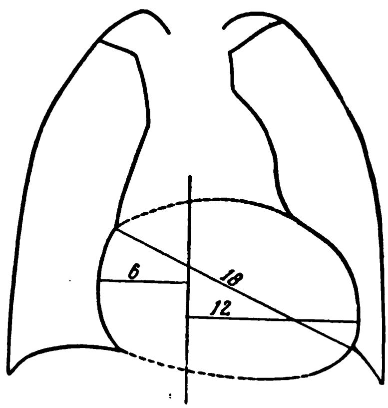

FIG. 113. ALCOHOLIC MYOCARDITIS. MAN 65 YEARS OF AGE

When the dilatation is very marked, it is not unusual to find a murmur of tricuspid insufficiency associated with the murmur of mitral insufficiency. This is shown in Fig. 114, where the dilatation affects all the cavities equally, but especially the right cavities including the auricle. In this case the right contour of the heart shows an extreme development from the cardio-vascular angle to the level of the diaphragm.

The radiological signs, therefore, of cardiac dilatation are characterized, at the outset, by a total increase of the area of the heart and its diameters (Fig. 112); at a more advanced stage the form of the shadow becomes perfectly globular with equal exaggeration of both diame-

ters (Fig. 113); finally, when the dilatation reaches a considerable degree, the outlines of the heart assume a triangular aspect with the base resting on the diaphragm (Fig. 115). Other signs of dilatation as shown by radioscopy are: the weakness of contractions which appear in the form of dragging undulations, and a peculiar deformation of the contours of the shadow occasioned by displacement of the organ.

In the following chapter, other examples will be found in which radioscopy was of value in diagnosis of dilatation of the heart and in the prognosis which it permits.

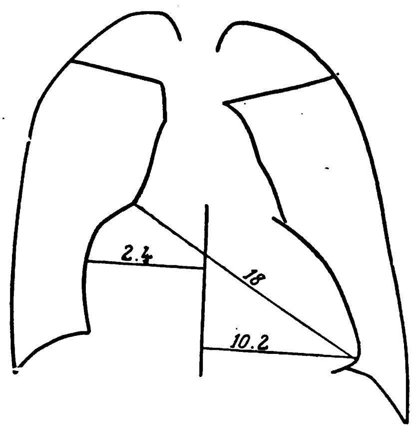

FIG. 114. ALCOHOLIC MYOCARDITIS

Considerable dilatation of the right cavities.

IV. BASEDOW'S DISEASE

The prognosis of Basedow's disease is closely related to the condition of the heart. Patients with this disease very often succumb to cardiac disturbances. For a considerable period there has been marked interest in the nature of the murmurs which are so commonly heard; these, according to some writers, are usually anorganic, while others think they are related to functional insufficiencies, transitory or permanent.

Fig. 115. TELERADIOGRAPH OF A CASE OF CARDIAC DILATATION

In the course of Basedow's disease murmurs may occur which are not referable to any change in the orifices, but the number of these cases appears more limited than Potain states. In fact these murmurs appear only in patients with severe forms of the disease, in whom a certain degree of cardiac insufficiency is present. The radioscopic examinations which have been made have, moreover, confirmed this, for they have shown that there was always a more or less notable degree of cardiac dilatation in patients with these murmurs.

Fig. 116 is the cardiogram of a patient forty years of age who had all the signs of Basedow's disease. The affection was severe, tachycardia was very pronounced, and there existed, also, with dyspnœa on exertion, a precordial distress indicating serious circulatory disturbance. On percussion the heart seemed slightly increased in volume, but its limits did not appear greatly exaggerated. Radioscopy showed that the cardiac dilatation had reached a much more advanced degree than was suspected. The right and left contours of the heart were exaggerated on both sides of the median line. The longitudinal diameter measured 16.7 cm., the horizontal, 16.4 cm. Moreover, fluoroscopic examination showed an interesting change seen during inspiratory displacements of the heart. The left contour, deformed in its middle third, was not convex but concave, as if the ventricular wall were in an excessively flaccid condition. This condition, especially noticeable during inspiration, and particularly in the recumbent position, appeared to be related to an abnormal flaccidity of the heart and to be of considerable prognostic importance, for it occurred in several cases of myocarditis and cardiac insufficiency. This impression was confirmed by the rapid and feeble pulsations of the heart. There is no doubt that in this case radioscopic examination corrected the auscultatory findings, for the impression obtained was that it was purely

an anorganic murmur, whereas the heart was seriously affected and the prognosis considered to be very grave.

Fig. 117 furnishes analogous indications. A case of a woman forty-nine years of age, with marked hypertrophy of the thyroid gland, exophthalmia, tachycardia and the heart enlarged on percussion. The condition of

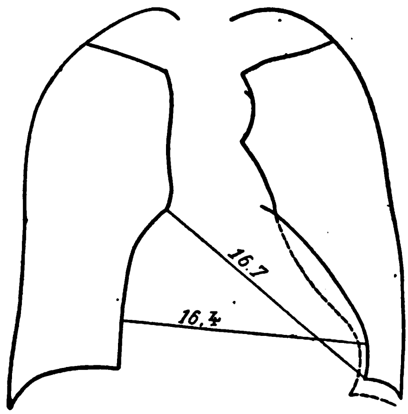

FIG. 116. DILATATION OF THE HEART IN A CASE OF BASEDOW'S DISEASE

The contour in dotted lines shows the deformation of the left outline during deep inspiration.

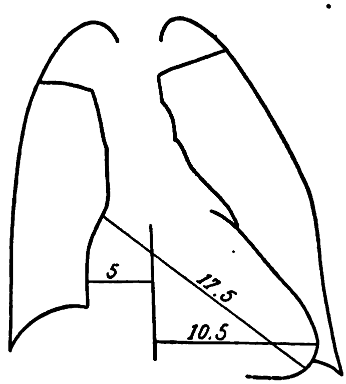

FIG. 117. BASEDOW'S DISEASE. FLACCID HEART

this patient, however, was complex. There were symptoms of renal origin: albuminuria, galloping sound, slight malleolar œdema. As the figure shows, the area of projection of the heart is notably increased, the apex is rounded, lowered, but the contour of the left ventricle is not convex as seen in the renal heart; marked concavity of the middle third of the left contour is also found, the pulsations rapid, feeble and retarded. Here dilatation predominates.

V. ARHYTHMIC HEART

The numerous radiological observations made of patients affected with arhythmia have led to some interesting remarks which will be only mentioned in passing. It would evidently be premature to say that characteristic outlines exist of such and such arhythmic types, for these may be associated with very diverse cardiac affections. Moreover, radiology should not be compared with graphic recording or other methods of examination, to demonstrate the nature of an arhythmia; but it is always worth while to use the results of fluoroscopic examination or orthodiagraphy to obtain supplementary information the interpretation of which may lead to results of real practical value.

We have examined several patients with paroxysmal tachycardia, in whom during the course of this arhythmia the question was determined whether the heart was enlarged. Certain writers, notably Martius, have stated that the heart was larger than normal. Hoffmann has not agreed with this opinion. A case is presented here which shows that Martius' opinion is erroneous. Fig. 118 represents, in the black lines, the orthodiagram of a woman thirty years of age, with paroxysmal tachycardia of auricular origin, whose history has previously been reported.[29] The tachycardia was unusual, since it ex-

[29] Vaquez et Pezzi, *Tachycardie paroxystique de type auriculaire.* Société médicale des hôpitaux, séance du 22 mars, 1912, p. 360.

ceeded 300 pulsations a minute. During the attack, as can easily be seen, the heart was of small dimensions, its longitudinal diameter measured 12.2 cm. and its horizontal diameter, 12.1 cm.

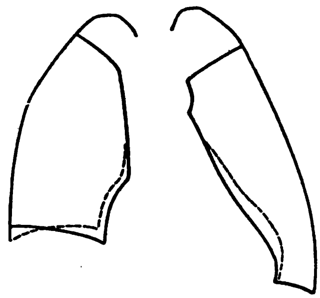

FIG. 118. PAROXYSMAL TACHYCARDIA

Black lines, contour during the attack; dotted lines, contour of the heart after the attack.

A second examination was made a week after the termination of the attack, the patient being in the same recumbent position and under the same conditions of examination. As the orthodiagram shows, the diameters of the heart have increased or rather they have resumed their normal dimensions: the longitudinal diameter is 13 cm. and the horizontal diameter is 12.4 cm. Moreover, on the screen, the pulsations, almost imperceptible during the attack, had become ample and forcible.

We have also examined several other patients with paroxysmal tachycardia in which the results agreed with these. The evidence in these cases has been sufficiently conclusive so that it is believed that diminution in the volume of the heart in the course of an attack is a usual phenomenon.

Chronic arhythmia, referred to as auricular fibrillation, is always a grave symptom, though a certain num-

ber of cases become compensated to this condition and suffer only moderately during a period of months or years. However, when it occurs in cases with valvular lesions, it is always the sign of cardiac insufficiency, the prognosis of which is based on the condition of the heart itself. Electrocardiograms and jugular tracings indicate only a marked modification in the type of contraction of the auricle, without giving information as to the condition of the other parts of the heart. Radioscopy shows that, together with cardiac changes consistent with the associated valvular lesion, there occur, sometimes, unsuspected changes and more or less marked dilatations which must be considered in making a prognosis.

The orthodiagraphic tracing in Fig. 119 is of a man thirty-nine years of age, subject for a long time to dyspnœa on exertion and palpitation. He had been obliged six months previously to give up his work as valet because the symptoms became so aggravated. On examination a systolic murmur was heard at the apex and at the same time a complete characteristic arhythmia. After some days of rest the signs of cardiac insufficiency

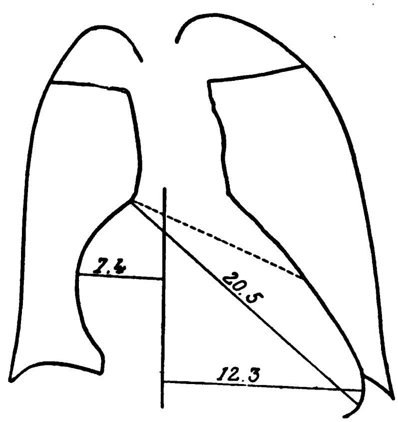

Fig. 119. CHRONIC ARHYTHMIA

Mitral disease. Dilatation of the heart.

appeared to be relieved and the only abnormal sign remaining was the persistence of the arhythmia. With only these indications it would have been difficult to determine the prognosis, since chronic arhythmia does not constitute, as we have just said, a sufficient sign of irremediable failure of the heart. But radioscopic examination showed, on the contrary, that there was reason for considering the prognosis as very grave.

The orthodiagram reproduces the usual image of a mitral lesion, which was also recognized by auscultation; but it demonstrates, moreover, an enormous development of the heart. On the other hand, in right posterior oblique position at 50 degrees, the left auricle obscured the retro-cardiac clear space, and at this angle the apex of the heart did not disappear behind the vertebral column. There was reason to infer then the existence of a marked dilatation of the heart with an increase of all the diameters. Some months later the patient reentered the hospital with severe symptoms of asystolism.

Irregularities of the heart, notably paroxysmal tachycardia and chronic arhythmia, often have the effect of muffling the stethoscopic signs of the associated valvular lesions. Sometimes it is the chronic arhythmia which, by modifying profoundly the mode of contraction of the auricles, suppresses the presystolic rumbling and renders difficult the diagnosis of mitral stenosis. Sometimes it is the paroxysmal tachycardia which, by a very different action, weakens the orificial murmurs or the presystolic rumbling to such an extent that they can no longer be recognized by auscultation. In these different cases radioscopic examination, by giving the characteristic outlines of this affection, makes possible a final diagnosis. An opportunity was given to examine two patients with paroxysmal tachycardia, in whom, during the attacks, it was impossible to determine whether or not a valvular lesion existed. Fluoroscopic examination showed that the patients were affected with mitral stenosis; the

diagnosis was confirmed by auscultation when the crisis had passed.

VI. CARDIAC INSUFFICIENCY AND ASYSTOLISM

We have had an opportunity in the course of these studies to observe several times the radioscope signs which enabled us to make a diagnosis of cardiac dilatation (which usually precedes asystolic symptoms and which accompanies myocardial insufficiency). To recognize the early dilatation does not only complete a diagnosis but it immediately establishes a prognosis; in order that this prognosis be of value, it must not be based only on the objective and subjective functional signs which are obtained by the ordinary investigation methods: peripheral stasis, œdema of the extremities, enlargement of the liver, marked dilatation of the right cavities with tricuspid insufficiency, etc. This prognosis has a greater value (since it leads to early therapeutic intervention) if it is still impossible to recognize in a patient the symptoms that precede cardiac insufficiency. In such cases as has been shown, radioscopy gives evidence of considerable importance. We merely mention the many cases in which early dilatation of the cavities without threatening symptoms was revealed by radioscopy, cases in which cardiac debility was marked, moreover, by the modification and retarding of pulsations along the ventricular contours, by flaccidness, and slight amplitude of the myocardial contractions, or in short by evidence of severe disturbances in the cardiac systole. Myocardial changes can therefore best be studied by radioscopy.

Several times we have had occasion to demonstrate the marked changes in the exterior appearance of the heart and to make an unfavorable prognosis because of the progressive cardiac dilatation and of the early appearance of the signs of asystolism. The different degrees through which a patient passes before chronic asystolism is reached could be determined and it was not surprising

after weeks or months to see the outline of the cardiac shadow change completely and assume the form of pronounced asystolic conditions. This is shown in Fig. 120, a man thirty-nine years of age with chronic asystolism.

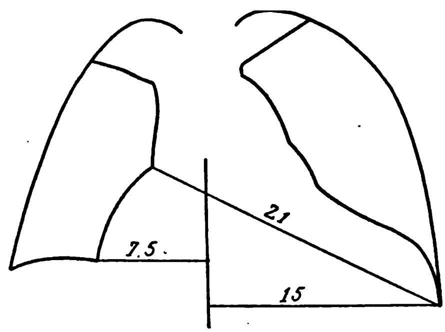

FIG. 120. ASYSTOLISM

The extreme dilatation of all the cavities is shown here as is seen by increase of the diameters, the longitudinal being 21 cm., the horizontal being 22.5 cm. The enlargements of the right auricle and ventricle are indicated by the considerable projection of the left contour, which is level with the external thoracic wall; moreover, the right diaphragmatic shadow is very high and is formed by an almost horizontal line, which indicates an enormous development of the liver.

CHAPTER VII

AFFECTIONS OF THE PERICARDIUM

A. PERICARDIAL EFFUSIONS

THE diagnosis of pericardial effusions should be, according to some writers, relatively easy. It is not always so in practice, and if fluid in the pericardial cavity is accompanied ordinarily on palpation by elongation of the heart apex, on percussion by increase of the cardiac dullness, and on auscultation by the disappearance of the normal sounds, nevertheless any one of these signs may be consistent with some other affection. Radiological examination is then of great value, because very often it shows in the heart outlines peculiarities which make diagnosis more positive. Unfortunately it is not always easy to proceed with such an examination, for it requires perfect radiological equipment and special precautions on account of the patient's generally serious condition.

Pericardial effusions bring about a combination of radiological signs, which are:

(a) Globular increase of cardio-pericardial shadow.

(b) Peculiar modifications of the form of this shadow.

(c) Diminution and sometimes even abolition of the cardiac pulsations.

(a) The increase of the cardio-pericardial shadow is sometimes considerable; the pulmonary fields are encroached upon by a shadowy mass, which enlarges from above downward and is at its maximum at the level of the line of the diaphragm. The result is an unusual elongation of the horizontal diameter, especially as compared with the longitudinal diameter. On Fig. 121, the

horizontal diameter is 19.5 cm., whereas the longitudinal does not exceed 17 cm. This fact, which is rather rare, although it may be found in cases of dilatation of the heart, is invariably the rule in effusions of the pericardium, and the difference between the two diameters is never so great as in this affection.

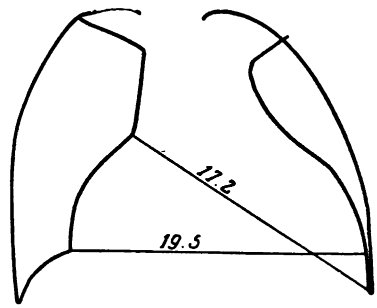

FIG. 121. PERICARDIAL EFFUSION

(b) The form of the cardio-pericardial shadow has a peculiarity which is not found in any other disease. First, as Dietlen has noted, the pedicule is very short, that is to say, the shadow has only a slight development in its middle portion, upward under the clavicle; moreover, from this point downward, the contours expand suddenly right and left, but especially to the left where the outline of the shadow takes an almost horizontal position, reaching the external portion of the thoracic wall (Fig. 122).

In these less accentuated cases the general form of the cardio-pericardial shadow is globular and similar to the image seen in myocarditis (Fig. 123).

(c) The study of the heart pulsations is particularly suggestive, and even in the cases in which the amount of fluid is not yet abundant, a very notable decrease of the pulsation is noticed, owing to the fact that the pulsation transmitted in all directions at once by the contact of the

heart with the fluid cushion arrives much weakened at the walls of the pericardial sac.

However, none of these findings is pathognomonic of an effusion in the pericardium. But if all three coexist, the diagnosis is usually correct independently of all negative or positive clinical signs. Béclère[30] has been able to establish radioscopically the diagnosis of chronic pericarditis and that of acute pericarditis with effusion, in cases which have finally been confirmed by the progress of the disease.

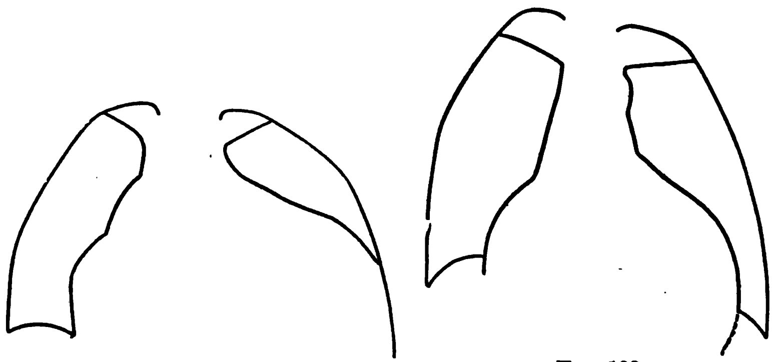

FIG. 122 FIG. 123

FIG. 122. LARGE PERICARDIAL EFFUSION

FIG. 123. MODERATE PERICARDIAL EFFUSION, OF TRAUMATIC ORIGIN

Nevertheless, radiological examination is not always sufficient to form a positive diagnosis, notably when the amount of fluid is not abundant and the heart is very much enlarged; its pulsations are then transmitted almost entirely to the limits of the pericardial sac.

Inversely, the markedly increased shadow of the heart due to cardiac dilatations may be mistaken for an effusion, for example, in alcoholic myocarditis. In this case, the increase of the cardio-pericardial shadow is accom-

[30]Béclère, *Traité de radiologie* du Pr. Bouchard, 1904.

panied by more or less marked feeble pulsations, and the combination of the two conditions might lead to a diagnosis of fluid.

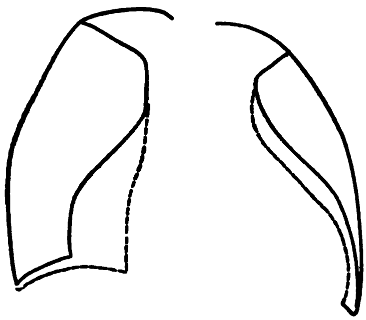

FIG. 124.

Black lines the contour of the shadow when the patient entered the hospital; dotted lines, contour of the heart a month and a half later; the effusion reabsorbed.

Lutembacher[31] has recently reported a case of aneurism of the left auricle measuring 400 cu. cm. which because of the considerable dimensions and configuration of the radioscopic tracing had been mistaken for a time for a pericardial effusion. But in the case of cardiac dilatation the form of the shadow differs from that of effusion; moreover, though the pulsations may be slight they never disappear completely; in a word, the radiological syndrome described above is not found.

Finally, radioscopy is the preferable method by which to study thoroughly the development of pericardial effusions. The progressive increase in the quantity of fluid and its diminution are interpreted by variations in the form and the diameters of the shadows, variations which are easily read on cardiograms or plates without deformations. Fig. 124, a man forty-two years of age with an exudative pericarditis, is an example in point. The con-

[31] Lutembacher, *Anévrisme de l'oreillette gauche.* Archives des maladies du cœur, des vaisseaux et du sang, avril, 1917.

tour in black lines shows dimensions of the cardio-pericardial shadow at the time when the pericarditis was at its height. The contour in dotted lines, taken a month and a half later, when there was improvement, indicates a very clear diminution of this shadow. In addition the pulsations, barely perceptible at the time of the first tracing, had become normal at the time of the second.

B. CARDIAC SYMPHYSIS AND PARTIAL ADHESIONS OF THE PERICARDIUM

The term cardiac symphysis, which designates the total adhesion of the two pericardial folds, is also applied to adhesions which unite the outer surface of the pericardium to the neighboring organs.

The multiplicity of anatomical forms of symphysis explains why the visible signs of this affection are so numerous and why they vary according to the location of the adhesions.

What is of utmost importance to know is first whether adhesions of the pericardium exist and then whether they are generalized or localized; whether the folds of the pericardium are simply united with each other; whether the heart is still mobile or is fixed to the costal wall, to the diaphragm and to neighboring organs; finally, whether there is at the same time a posterior mediastinitis. It is the more important to solve these questions because the treatment of pericardial symphysis depends, in a certain measure, on surgery, and before proceeding with surgical intervention it is indispensable to know what results it may have. The indications and the counter-indications of Brauer's operation can be fixed only by radioscopic examination of the adherent heart. This accounts for the long explanation that is given of this question.

Pericardial adhesions cause the many and varied modifications of the cardiac image, modifications which may be called immediate or mediate according as they

are in direct or indirect relation with the adhesions. Among the first to be mentioned are changes in the general appearance of the heart, in the extent of its displacements occasioned by different positions of the body, in the amplitude of the movements of the diaphragm and of the costal wall, etc. Among the second: concomitant changes in the lungs, in the pleura and the diaphragm, enlargements of the heart caused by associated lesions, etc. To recognize these it is necessary to employ all the radiological methods: fluoroscopic examination, orthodiagraphy, teleradiography. The study of this subject will be taken up as follows:

I. General data from radiological examination.

II. Particular data relative to the existence of pericardial adhesions.

III. Data relative to the location of the adhesions.

IV. Comparison of the results of percussion and orthodiagraphy.

V. Clinical observations.

I. GENERAL DATA FROM RADIOLOGICAL EXAMINATION

The preliminary examination of the shadows of the thoracic cavity gives information on the condition of the lungs and the pleura. This study demands the greatest care, for some radiological signs may be common to symphysis and to other cardiac affections.

a. *Pulmonary field.* Certain pulmonary affections, notably tuberculosis, give rise to respiratory disturbances due to the lack of elasticity of the lung and are accompanied by diminution of the amplitude of the diaphragmatic and rib movements. These disturbances occur also in patients who have pericardial adhesions. But before attributing them to this latter affection it is necessary to make sure that tuberculosis is not the cause. That is recognized by the existence of characteristic shadowy areas. However, the question of differential diagnosis

is not settled by the fact of having verified the presence of pulmonary tuberculous lesions, for these coexist frequently with certain forms of chronic pericarditis. The object of radiology here is only to determine as exactly as possible the anatomical condition of the lungs and the influence which the parenchymal lesions may exert on the movement of the diaphragm and the ribs.

In cases where there is reason to think that certain functional disturbances are due to pericardial adhesions, this opinion is confirmed if radiological examination of the lungs is negative.

b. *Pleural shadows.* It will be necessary first to determine whether the functional disturbances which might suggest pericardial symphysis, are not due simply to the presence of a pleural effusion which can always coexist with pericardial symphysis.

Also pleuro-pulmonary adhesions may be mistaken for pericardial symphysis, for like it they cause changes in the respiratory displacements of the thoracic organs and changes in the position of the heart. In that case the radiological findings are most important; if they show that the pleuræ are free from adhesions, that will establish a strong presumption in favor of the diagnosis of cardiac symphysis. But this diagnosis ought not to be rejected in case pleuro-pulmonary adhesions are found, for they frequently exist with pericardial symphysis. The diagnosis of this affection will then depend on other clinical and radiological signs.

c. *Mediastinal shadows.* Examination of the mediastinum in the frontal position allows the elimination of tumor of the mediastinum as a cause of functional disturbances, for, if one exists, it will be easily recognized by the aspect of its contours.

This done, the next thing is to make radiological observations of the anterior mediastinum and the posterior mediastinum in oblique and lateral positions.

In the normal and in these positions, the anterior

mediastinum appears as a clear space between the shadow of the heart and that of the sternum. If there are adhesions uniting the pericardium with the sterno-costal wall, this space is reduced or completely disappears.

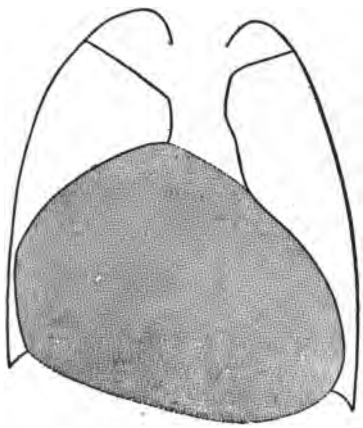

FIG. 125.

Considerable increase in the volume of the heart in a patient 20 years of age with cardiac symphysis.

It is the same with the retro-cardiac transparent area, when there is posterior mediastinitis.

d. *Volume of the heart.* It is hardly necessary to state that the heart shadow should be determined with the greatest care, either by distant radiography or orthodiagraphy.

In the cases which are of interest here the heart always shows enlargement. The right and left contours are markedly developed (Fig. 125), and hypertrophy of the heart is sometimes accompanied by a marked lowering of the apex. This can be due exclusively to the symphysis without any associated valvular lesion. But if symphysis does exist at the same time, radiological examination will allow the usual descriptive characteristics to be noted. Thus in the patient shown in Fig. 126 signs of double

mitral lesion are recognized; salience, above point G, of the pulmonary artery, and of the auricle compressed by the dilated left auricle; increase of the left ventricular contour; apex pushed outward, etc.

II. DATA RELATIVE TO THE EXISTENCE OF PERICARDIAL ADHESIONS

Pericardial adhesions show radiologically in two ways: either they are directly visible on the screen and on the plate, because they are sufficiently dense to throw a shadow and because they occur in regions normally trans-

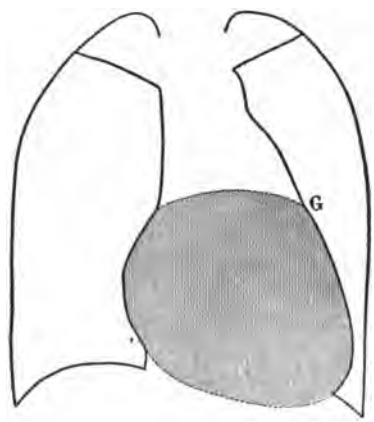

FIG. 126. DOUBLE MITRAL LESION IN A PATIENT WITH SYMPHYSIS

parent; or they are not directly perceptible and are indicated only when affecting the mobility of the heart and the adjoining organs during respiration or during changes in the position of the body.

a. *Shadows on the heart outline due to adhesions.* These shadow outlines are best studied closely on a radiographic plate. They have been described by Beck,[32]

[32] Beck, *Roentgen Ray, Diagnosis and Therapy,* Appleton & Co., New York.

Benedikt,[33] Sturtz,[34] Moritz,[35] Lehmann and Schmoll.[36] They are irregular according to Lehmann and Schmoll, jagged, bordering both sides of the heart shadow and making its contour vague and indistinct. These shadows are due to extensive adhesions; at the site of the adhesions the pulsation of the heart is effaced. (Fig. 127.)

In a case reported by Sturtz he says that "one can clearly see adhesions at the left border of the heart and at the summit of the left diaphragm. Starting from these areas fine shadows of adhesions are also seen."

Lehmann and Schmoll state that it is necessary to distinguish these shadows from those which are attributed "to symptoms wholly pleural which have no direct bearing on the pericardium but which are simply superimposed upon the projection of the heart shadow. On the other hand, the indentations, the points, the irregularities of the contour of the heart due to pericardial adhesions are marked in too clear a manner to be explained by the unreliable evidence against which Moritz warns."

Besides these indentations in the contour of the heart the writers have described shadows obscuring one or both of the angles formed by the heart and the diaphragm. Lehmann and Schmoll have published radiographs showing these shadows which enabled them to diagnose pericardial diaphragmatic adhesions.

Béclère[37] says on this point: "In the normal state the right and left sides of the cardiac shadow curve in slightly toward the median line before meeting the contour of the shadow of the diaphragm, in such a way that they limit with this shadow two very small sinuses which may be called the cardio-diaphragmatic sinuses. In deep

33 Benedikt, *Weiner med. Woch*, 1900, no. 9.

34 Sturtz, *Fortschritte auf d. Gebiete d. Roentgenstrahl*, Bd. VIII, Heft. 5.

35 Moritz, *Münch, med. Woch.*, 1900, no. 29.

36 Lehmann et Schmoll, *Fortschritte auf d. geb. d. Roentgenstrahl*, Bd. IX, 1905-1906, p. 196.

37 Béclère, *Traité de radiologie médicale du Pr. Bouchard*, 1904.

FIG. 127. SHADOWS OF PERICARDIAL ADHESIONS, AFTER LEHMANN AND SCHMOLL

inspiration these two sinuses become in the normal larger and deeper, as if the heart separated from the diaphragm. On the contrary, if pericardial symphysis exists, the two sinuses disappear almost completely, and the contour of the cardiac shadow, in the neighborhood of the diaphragmatic shadow, invariably keeps the same form at the end of expiration and inspiration."

When adhesions are present on the contour of the heart the shadows are seen on the screen and especially on the plates; on this point our observations confirm those already cited. However, the presence of these shadows is far from being constant, and we have rarely found them. As to the costal-diaphragmatic or cardio-diaphragmatic sinuses being obscured, to which Lehmann and Schmoll attribute great importance as a sign of adhesions, it has not, in our opinion, that significance except with certain reservations.

In the first place it may happen that the increase in density of the pericardial folds, at the point of their left phrenic insertion, may produce an obscurity which is purely physiological. The disappearance of the cardio-hepatic sinus may be due to a similar thickening of the folds of the pericardium, or to an abnormal distention of the inferior vena cava, or even to an inflammation or dilatation of the right ventricle. Finally, it sometimes happens that the left cardio-diaphragmatic sinus is covered by the hypertrophied heart.

Now, it is rather difficult to be sure that these conditions do not intervene in the obscuring of the cardio-diaphragmatic sinuses, which makes the value of this sign somewhat uncertain. The radiographic plates which ought to be useful are technically often defective, however carefully they are taken.

On the contrary, the signs about to be studied are in more direct relation to the adhesions at the apex of the heart.

b. *Modifications of displacements of the shadow of*

the heart and of the diaphragm. Displacements of the heart observed in the physiological state are caused either by changes in the position of the body or by respiration which modify the intra-thoracic pressure. These displacements are naturally more or less reduced or even rendered impossible if the heart is attached to the thorax or to the neighboring organs by adhesions. It is important therefore to make a detailed study of them. These displacements affect either the heart as a whole or more especially its apex.

1. Apex of the Heart. The apex of the heart, normally mobile, is displaced outward from 2 to 2.5 cm. when the body is inclined toward the left; moreover, it descends and rises during inspiration. It is the amplitude of these displacements, the *lateral displacement* and the *vertical displacement* that must be observed in order to know the degree of mobility of the apex.

If the *lateral displacement is abolished,* the contours of the cardiac shadow, traced on the skin of the patient, first in the vertical position, then in the left inclination, are exactly superimposed. Sometimes the immobility both of the ventricular contour and of the apex is complete; or, the apex being very clearly fixed, the ventricular contour alone is displaced slightly outward. Then, especially if the heart is large, the left ventricle is seen to fill markedly during the change of position until it pushes against the thoracic wall (Fig. 128), whereas the position of the apex remains unchanged.

When the lateral displacement only is reduced, the successive contours which indicate the apex are very close together. This sign is found in cases where the apical adhesions are loose; but adhesions of the right side of the heart may produce the same effect.

The mobility of the apex does not exclude the diagnosis of pericardial adhesions nor does its fixity establish the diagnosis. In fact, we have always found the apex fixed in cases of adhesions, but, theoretically, it is conceivable

that adhesions, confined to the base of the heart, should leave the apex mobile. On the other hand, it is not conceivable that other causes than adhesions should be capable of completely immobilizing the apex of the heart. In practice a considerable cardiac enlargement may have the effect of pushing it against the thoracic wall and on the diaphragm which becomes depressed and thus offers complete resistance to displacement of the apex. The result will be an error in interpretation which will therefore lead to a wrong diagnosis.

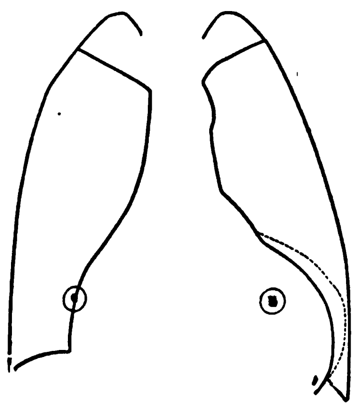

FIG. 128. IMMOBILITY OF THE APEX WITH MOVEMENT OF THE LEFT SIDE TOWARD THE EXTERNAL THORACIC WALL DURING INCLINATION OF THE BODY TO THE LEFT

Dotted lines, contour of left side during inclination. Apex fixed at level of the cross.

Vertical displacement of the apex is observed during respiratory movements. During deep inspiration the apex is lowered and moves slightly inward; during deep expiration the apex is raised and moves outward. In cardiac symphysis these displacements are usually diminished or abolished.

The following conditions may occur:

(a) The adhesions fix the apex to the thoracic wall.

The apex is then not associated with the movements of the diaphragm but maintains constant relations with the thorax.

(b) Adhesions fix the heart to the thoracic wall and to the diaphragm. The vertical displacements of the apex are much diminished or disappear, and the movement of the left diaphragm is much reduced, at least in its medial portion.

(c) Adhesions exist only between the apex and left diaphragm. In this case the lateral displacements are abolished and the vertical movements remain. The apex, fixed to the diaphragm, lowers and rises during inspiration and expiration. This sign should be accepted only with reservation as a sign of local symphysis, when the heart is enlarged. It may be added that absence of vertical displacements does not always mean that the apex is adherent, for solid adhesions of the anterior surface may make the whole organ immobile.

2. Displacements of the Heart Outlines. Briefly, the heart, during respiratory movements, undergoes marked displacements which not only lower it and elevate it as a whole in the thoracic cavity but which result in deformations of its contours: in deep inspiration the cardiac shadow is elongated and contracted, whereas in forced expiration it broadens and is enlarged from right to left.

All these modifications may be completely transformed if adhesions exist. The respiratory displacements are sometimes less extended on one side, either to the left or right (Fig. 129); sometimes a small part of one of the contours is less mobile; at other times one of the sides remains fixed while the other is displaced (Fig. 130); and, finally, the entire contour of the heart is sometimes displaced, excepting the apex which remains immobile (Fig. 131).

These variations are explained by the different positions of the adhesions.

If, for instance, the left side only is attached to the

costal wall to a slight extent, it can be assumed that the heart does not follow the diaphragm in its inspiratory movement, and since the rest of the organ is free, the right side retains its normal movements.

When the adhesions of the left side or of the anterior surface of the heart are extensive and very adherent, the contours of the heart are absolutely immobile and the lines which mark them on the screen successively during inspiration and expiration are exactly superimposed.

It may happen in certain cases that a rather paradoxical phenomenon is found, namely, elevation of the contour of the heart during deep inspiration, the opposite of what happens normally. This is explained by the close adhesion of the organ to the sterno-costal plastron; the heart consequently follows the forward and upward movements of the sternum during inspiration. For this to occur it is necessary that the lower region of the heart be free from adhesions and that the bottom of the pericardial sac be sufficiently extensible so that the heart is not pulled during the lowering of the diaphragm.

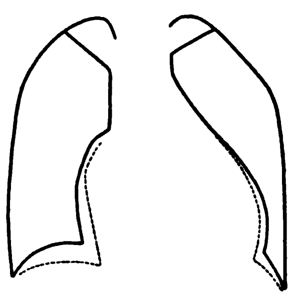

FIG. 129

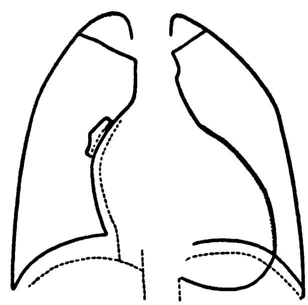

FIG. 130

FIG. 129. M., 16 YEARS OF AGE

The respiratory displacements of the heart are much reduced, especially on the left.

FIG. 130. LEON P., 7½ YEARS OF AGE

Immobility of the left contour. Diminished mobility of the right contour during respiratory movements.

Finally, if the lower part of the heart, the diaphragm, and the thoracic wall are closely united on one side, there will be no displacements in this region, but fairly ample ones on the other side.

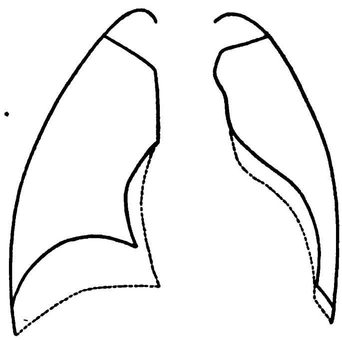

FIG. 131. TH., 20 YEARS OF AGE

The contour in dotted lines shows that in deep inspiration the heart is lowered, except the apex.

3. MOVEMENTS OF THE DIAPHRAGM. The pericardium is inserted in the center of the diaphragm, the two halves of which, the right and left, have in the normal almost synchronous downward and upward movements.

The right dome of the diaphragm is a little more elevated than the left because of the position of the liver. The movements are, on the contrary, generally somewhat more extended on the right. According to Lange[38] they should be 3 cm. on the right, 2.8 cm. on the left in deep inspiration. During quiet inspiration they should be 1.25 cm. on the right, and 1.2 cm. on the left. Taking successively the orthodiagraphic tracings in deep inspiration and expiration we have found higher figures for the distance between the centers of the domes of the diaphragm, 3.5 cm. to 4.5 cm. on the right, 3 cm. to 4 cm. on the left,

[38] Sidney Lange, The Relations of the Diaphragm as Revealed by the Roentgen Ray, *Journ. of Amer. Med. Assoc.*, Feb., 1908.

in man. In woman the amplitude of these movements is less.

If for some pathological reason one of the diaphragms is rendered immobile or its movements merely reduced, the other diaphragm may keep its normal degree of excursion (Figs. 129, 130, 131, 132).

When there is no pathological disturbance in the lungs, the pleuræ, and the liver to explain the diminutions of the diaphragmatic movements, the modifications observed are attributable to adhesions between the heart, the pericardium and the diaphragm. The mobility of the phrenic muscle is only slightly diminished by these adhesions. To have it reduced or abolished, it is necessary that the pericardium and the heart adhere on the other side, either to the thoracic wall or to the organs of the posterior mediastinum.

When a patient is examined, one should not be content simply to mark with two superimposed points the maximal distance of the excursion of the diaphragm. All the outlines of the contours of the phrenic muscle by the

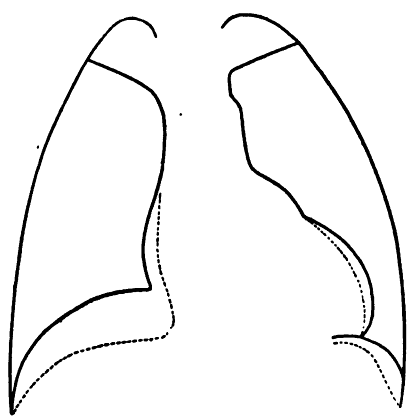

FIG. 132. THE EXPANSION OF THE DIAPHRAGM IS MUCH REDUCED ON THE LEFT IN THE INNER THIRD, A LITTLE FULLER IN THE OUTER TWO-THIRDS, NORMAL ON THE RIGHT.

orthodiagraphic method give, in certain cases, interesting information: the movement of the two diaphragms is sometimes immobilized in part, the inner portion for example, while the outer or costal portion shows decided movements up and down (Fig. 132).

It is often interesting to study the movements of the diaphragm in vertical position and in dorsal recumbency. The normal forced inspiration lowers the dia-

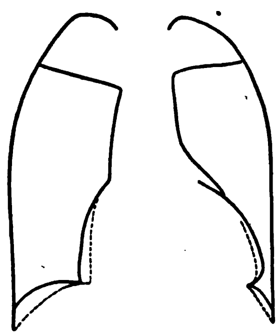

FIG. 133

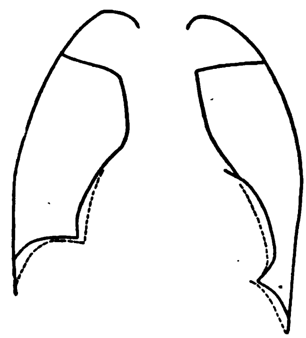

FIG. 134

FIG. 133. GERMAINE D., 11½ YEARS OF AGE

Diminution of the excursion of the diaphragm in vertical position.

FIG. 134. SAME CASE

Equally marked diminution of the excursion of the diaphragm in recumbency.

phragm and the heart much less in the vertical position than in recumbency. If the heart is large, as is generally the case in cardiac symphysis, the organ, by its own weight, depresses the diaphragm, especially on the left, and obstructs its movements. In order to make sure that the decrease of excursion is not due solely to this cause, a second observation in recumbency should be made, the position in which the weight of the heart has no effect. If as marked a reduction of the movements is found, then the hypothesis that adhesions reduce the excursion of the diaphragm (Figs. 133 and 134) can be considered.

By examining the movement of the diaphragm, the mechanism of a sign described by Broadbent,[39] which consists in the systolic retraction of the posterior thoracic wall at the level of the lower ribs, can also be explained. It can be done by fixing an opaque index over the region

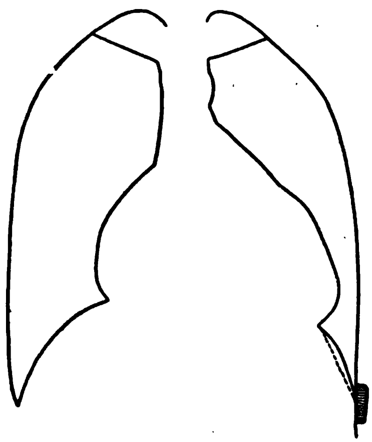

FIG. 135. PATIENT EXAMINED IN SLIGHTLY OBLIQUE POSITION (RIGHT ANTERIOR)

On the left thoracic contour the shadow of the lead index is shown situated in the zone in which appears Broadbent's sign. In dotted lines, the contour of the diaphragm stretched at each systole.

of the maximum movement of retraction; then it is seen, if the patient is placed obliquely, that this index corresponds exactly to the posterior costal insertions of the diaphragm and that the muscle is under tension at each cardiac contraction (Fig. 135). It is necessary, then, to obtain Broadbent's sign, that the heart and the pericardium should adhere not only to the diaphragm but also to the anterior thoracic wall. However, this sign is of no pathognomonic value. It is found independent of cardiac symphysis when pleural adhesions diminish the diaphragmatic movement and when the heart, increased in

[39] Broadbent, Diseases of the Heart, London, 1897.

volume and strongly depressing the diaphragm, transmits its pulsations to it.

4. Outline of the Heart. By placing the patient in the lateral position, the anterior outline of the heart can

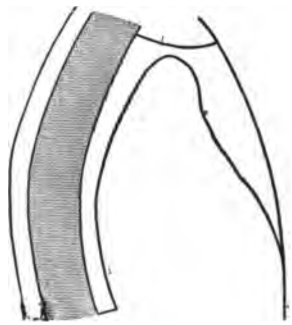

Fig. 136. M., 25 YEARS OF AGE

Symphysis of the heart and the anterior wall. In right lateral position, the anterior clear space disappears in its lower half during forced inspiration.

be traced behind the sternal border. In the normal, they are separated by a clear triangular zone which is very wide at the level of the vessels and grows narrower as it approaches the shadow of the diaphragm. This clear zone grows wider and becomes clearer during deep inspiration.

If the heart is attached to the anterior thoracic wall, it becomes impossible to find the anterior clear space, even with forced inspiration (Fig. 136).

This sign, in spite of its value, is not, however, pathognomonic. It is found in cases in which there are no adhesions, notably when the heart is considerably hypertrophied. On the contrary, if the retro-sternal clear space keeps its normal transparency, it is safe to say that there is no adhesion between the heart and sternal border, on condition, however, that the radioscopic examination has been made exactly at an angle of 90 degrees.

c. *Respiratory outline.* The study of the respiratory outline of the thorax, that is, the movements of projection and retraction of the sternum, observed with the patient in the lateral position, does not belong exclusively to the domain of radioscopy. Wenckebach has made use of photography to establish the details. But observation by orthodiagraphy is easièr and quicker, and we usually use this method.

In the normal the two lines which indicate the respiratory outline in deep inspiration and expiration are equidistant in the greater part of their length; they unite at the level of the abdominal region (Fig. 137).

This respiratory outline should always, according to Wenckebach, be markedly modified in case of cardiac symphysis. The sternum should then maintain, in its lower third, such a degree of immobility that the two lines which represent its displacement should cross at a fixed point (Fig. 138).

The crossing of the two lines, otherwise called the "crossed outline" of Wenckebach, is, to be sure, very rare. We have met it only in cases of adhesions of the

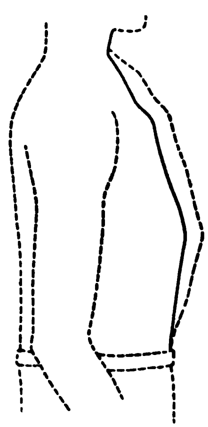

FIG. 137. NORMAL RESPIRATORY OUTLINE
Black line, deep expiration; dotted line, deep inspiration.

base of the heart. Less value should be attached to the simple diminution of the divergency of the two outlines (Fig. 139), which is merely a suggestive indication. On the contrary, its absence should not cause the rejection of the diagnosis of cardiac symphysis, as has been noted, when pericardial adhesions were present.

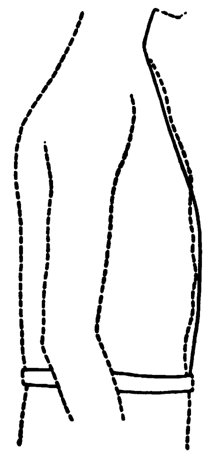

FIG. 138. CROSSED RESPIRATORY OUTLINE, ACCORDING TO WENCKEBACH

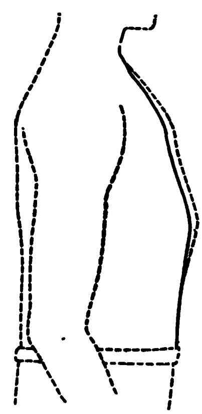

FIG. 139. RESPIRATORY OUTLINE OF SLIGHT EXCURSION

III. PARTICULAR DATA RELATIVE TO THE SITE OF ADHESIONS

In this study, adhesions will not be considered which unite the two folds of the pericardium, the heart remaining mobile in the united sac. These adhesions are not accompanied naturally by any fluoroscopic modification. Besides, they have not much importance; they do not give rise to functional disturbances and Laënnec stated that this condition did not constitute a real disease of the heart. Only cases which are clinically important will be considered in which the heart united to its pericardial sac has consequently contracted adhesions with the thoracic wall, mediastinum and diaphragm.

1. Adhesions of the Base of the Heart. These can be demonstrated by the following signs:

a. *Irregular notched shadows on the upper contour of the heart.* These shadows sometimes occupy a large surface and extend round the great vessels or toward the thoracic wall. Their visibility is not constant and depends on their development outside the sterno-vertebral and cardiac shadow.

b. *Absence of lateral displacements of the base of the heart.* In the left lateral inclination, the displacements of the organ, which are rather slight in the normal, are absolutely non-existent.

c. *Diminution or abolition of the respiratory displacements of the heart in the upper third of its projection.* During deep inspiration, for example, the upper contour of the heart remains immobile, while toward the apex, the shadow of the organ is elongated and consequently lowered.

d. *Slight modifications of the mobility of the diaphragm.* The excursion of the diaphragm is slightly diminished during deep respiration, as a result of the fixity of the base of the heart.

2. Adhesions of the Apex.

a. *Presence of shadows of adhesions.* If the heart is

not too large, we see the denticulations made by the shadow of the adhesions projected all round the apex; they unite with the diaphragm and obscure the left cardio-diaphragmatic sinus.

b. *Immobility of the apex.* The immobility of the apex is absolute in the lateral direction and almost complete in the vertical.

In order to affirm that adhesions are localized only at the apex, it is necessary to prove the persistence of displacements of the left side, to the exclusion of the apex.

3. Adhesions in the Diaphragmatic Region. a. The adhesions exist only between the lower edge of the heart, the pericardium and the diaphragm. They extend either to both diaphragms or to only one. In the first case, *the movements of the two diaphragms are appreciably diminished,* especially during deep inspiration and in the inner portion of their contour. In the second case, the difficulties of diaphragmatic excursion appear only on one side.

b. In most of the adhesions above, the pericardium is in symphysis with the thoracic wall. The diaphragmatic movements *are then greatly reduced, sometimes abolished in the greater part of their contour.*

The value of these observations is relative. Their bearing on the symphysis will be established only if no thoracic lesion exists (such as simple pleuro-pulmonary adhesions) capable of reducing the field of excursion of the diaphragm.

4. Adhesions to the Anterior Thoracic Wall. When large adhesions fix the anterior surface of the heart to the thoracic wall, *the movements due to the displacement of the body and the respiratory movements of the organ are much diminished, or abolished, or occasion the paradoxical phenomenon of inspiratory raising of the heart.* The fixity of the organ *hinders the excursion of the diaphragm whose movements are reduced.* In lateral position, *the retro-sternal clear space remains dark* during forced inspiration.

5. Posterior Mediastinitis. Posterior mediastinitis has only a secondary interest, but as it may complicate cardiac symphysis, it is necessary to know whether it exists or not. For this radioscopy in the oblique position is used. In this position, as Lambour[40] reminds us, following Holzknecht, von Dehn, and Radonicic, mediastinal involvements manifest themselves by shadows which obscure the retro-cardiac clear area.

6. Complicated Cases. In order to present as precise a description as possible of the findings of radiology in cases of pericardial adhesions, they have to be schematized. It is evident that in practice more complicated situations are met with, for adhesions may exist at the same time in different regions. The signs which have just been described will then be found associated, but the diagnosis will not on that account be rendered more difficult. It will demand simply more minute attention. It may be added, however, that more frequently than is thought, the adhesions affect in their disposition one or the other of the areas which have been described.

IV. COMPARISON OF THE RESULTS OF PERCUSSION AND ORTHODIAGRAPHY

Radioscopy and percussion give some information common to both and other findings which are special to each method. So these two methods, far from being mutually exclusive, assist each other and thus increase the means of diagnosis.

Common Findings. Orthodiagraphic tracings and the tracings of percussion taken in the frontal or direct anterior position can most often be superimposed. They both give the measure of the heart area, its degree of hypertrophy or of dilatation. However, orthodiagraphy is more accurate than percussion in outlining exactly the contour of the right side. The same is also true for the position of the apex and its degree of mobility.

Findings Peculiar to Radiology. These concern more

40 P. Lambour, Thèse de Paris, 1911.

especially the shadows of adhesions on the contours of the heart, the respiratory displacements of the organ, the modifications of the diaphragmatic movements, the obscuring of the anterior and posterior mediastinum.

Findings Peculiar to Percussion. The most important is that which establishes the relation of absolute to partial dullness. It is known that very often in cardiac symphysis, the surface of complete or absolute dullness is considerable. The nature of this clinical sign, the value of which has always appeared to us important, is not here interpreted. It need only be said that no radiological sign corresponds to it: the shadow of the heart projected on the screen or on the plate corresponds only to the surface of relative dullness.

Another sign obtained in certain cases by percussion consists in the invariability of the line of cardiac dullness during inspiration and expiration. This is explained by an adhesion of the heart to the sterno-costal wall, such an adhesion that pulmonary tissue no longer lies between the edge of the heart and the wall during profound inspiration, which suppresses all difference of sound on percussion.

It is evident that this sign relates to percussion only because it consists in tone modifications. But it can always be rectified by examination on the screen, which sometimes will show an absolute immobility of the contours of the heart which percussion might have missed.

It should be noted, however, that Ceyka has doubted the value of this sign and according to him immobility of the pulmonary outlines might cause it as well as pericardial symphysis.

V. CLINICAL EXAMPLES

The following cases are reported to demonstrate the value of radiological examination in the diagnosis and position of pericardial adhesions.

The first is a case of symphysis of the apex in which the radiological signs confirmed the clinical diagnosis.

Th. L., twenty-two years of age, subject to rheumatic attacks since five years of age, has been in the hospital frequently. He entered our service January 7, 1909, with marked dyspnœa associated with painful palpitations.

Clinical examination. Apex in the fifth intercostal space pushed slightly outward. Apparently displaced half a centimeter when the patient changed from the dorsal to the left lateral recumbency.

Seesaw movement of the wall with systolic elevation of the apex and systolic retraction of the wall in the fourth intercostal space two fingerbreadths above and inward from the nipple line.

Broadbent's sign at the left.

The outline of the heart on percussion gives: area of relative dullness increased, measuring 120.65 square centimeters; increase of absolute dullness.

Auscultation: diastolic murmur at the aortic area transmitted along the right border of the sternum; double crural murmur.

Pulse regular, bounding, 54 pulsations a minute.

Systolic tension, 16-17 (sphygmo-signal).

Liver slightly enlarged, overlapping the false ribs two fingerbreadths.

Clinical diagnosis: aortic insufficiency, pericardial symphysis.

Radiological examination:

Dimensions of the heart. Area of projection, 127 square centimeters. Left side, 15.6 cm. long; right side, 8.3 cm. Longitudinal diameter, 16.8 cm.; horizontal diameter, 15.3 cm. Apex rounded, lowered, pushed outward. Marked hypertrophy of the left ventricle (Fig. 140).

Respiratory displacements of the heart. During deep inspiration and expiration, the displacements of the heart contours are very marked; they are normal on the right, but on the left side, especially the middle part, they are

very great, *whereas there are no displacements at the level of the apex* (Fig. 141).

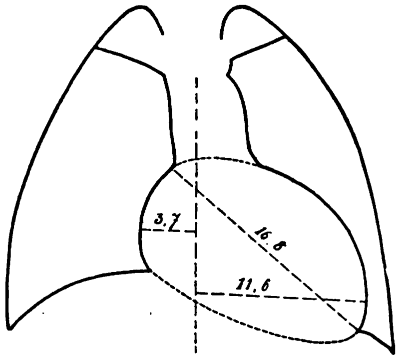

FIG. 140. TH. L. SYMPHYSIS OF THE APEX

Aortic insufficiency. Hypertrophy of the left ventricle.

Apex of the heart. It is immobile during left lateral inclination. When the patient is inclined far to the left, the contour of the shadow of the left ventricle, above the apex, approaches the external thoracic wall.

Movements of the diaphragm. During deep inspiration, the right diaphragm is depressed 4.5 cm., whereas the left has a reduced displacement of about 0.5 cm. (Fig. 141).

Outline of the heart. In lateral position at 90 degrees, the retro-sternal clear space is not visible in its lower third, even during forced inspiration.

Respiratory outline. Form normal, ample.

No abnormal shadows on the heart contour, nor in the pulmonary field.

Conclusion. Signs of adhesions of the heart apex. Its immobility and the greatly reduced movements of the left diaphragm can be explained only by the fixation of the apex to the anterior thoracic wall on one side and to the left diaphragm on the other.

In another case, the adhesions were on the anterior and superior surfaces of the heart.

H., 15 years of age, entered *la salle Lorain* in June, 1911, for dyspnœa. No rheumatism in his history. Objective examination shows the apex beat in the sixth intercostal space in the nipple line. It is immobile when the patient passes from dorsal to lateral recumbency. Auscultation gives a systolic murmur of mitral insufficiency, accentuation of the second pulmonic sound. Broadbent's sign on the left.

Orthodiagraphy gives the following (Fig. 142):

(a) Absolute immobility of the apex in lateral displacements; slight mobility in vertical displacements.

(b) Very marked diminution of the respiratory displacements of the left side, which presents in its upper third, to a slight degree, the paradoxical sign of inspiratory elevation in the vertical position. On the right, the respiratory displacements of the heart are maintained.

(c) Diminution of the excursion of the diaphragm, both sides, especially left.

(d) Cardiac area moderately increased: longitudinal diameter, 15 cm.; horizontal diameter, 15.5 cm.

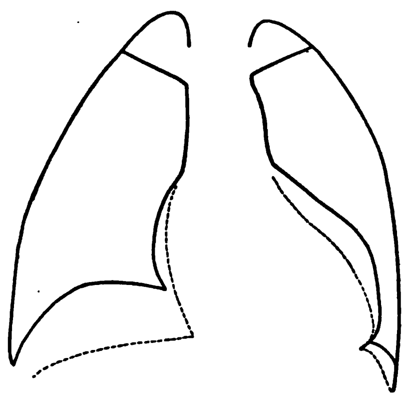

FIG. 141. TH. L. IMMOBILITY OF THE APEX

Respiratory displacements of the right and left contours of the heart of normal size, excluding the apex. Marked diminution of left diaphragmatic movement.

(e) Respiratory outline reduced.

Conclusion. The clinical signs warrant the diagnosis of cardiac symphysis. Radiological examination localizes the adhesions on the anterior surface of the heart because of modifications in the respiratory displacements of the left side and the lateral immobility of the apex.

These cases will suffice to illustrate the method followed in examining by fluoroscopy patients supposed to have pericardial adhesions.

There are cases, however, in which no positive diagnosis can be made. Ordinarily, these are young patients with valvular cardiopathies, most often aortic, and at the same time with considerable cardiac hypertrophy which, in a degree, immobilizes the heart. In these cases, the radiological and the clinical signs may easily be mistaken for symphysis. In a case like this which we examined (Fig. 143), there was a clear rolling movement on the surface of the heart, almost complete immobility of the apex, systolic retraction of the last intercostal spaces posteriorly and to the left (Broadbent's sign); in addition to these signs there was a slight decrease of the respiratory displacements of the heart and a very marked

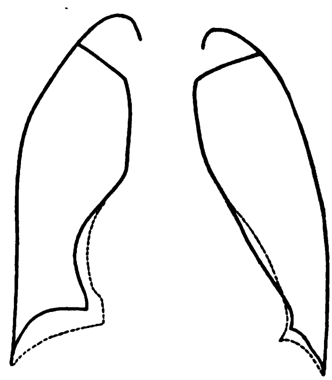

FIG. 142. L. H., 15 YEARS OF AGE.

Adhesions of anterior surface of heart. Black lines, deep *expiration.* Dotted line, deep *inspiration.*

diminution of the diaphragmatic movement on the left. This combination of symptoms led to the assumption that pericardial adhesions existed. Autopsy, however, showed that there were none and also explained the error in

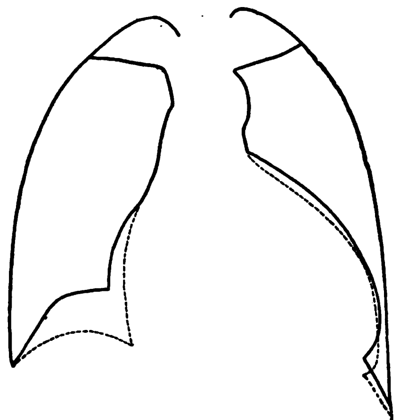

FIG. 143. V., 20 YEARS OF AGE. *COR BOVINUM*
Pleuro-pulmonary adhesions. No cardiac symphysis.

interpretation. The weight of the greatly enlarged heart pressed on the diaphragm which it rendered immobile; its mass was such that it prevented respiration affecting the normal heart changes. Finally, contact of the ventricle with the wall over a large area prevented the lung from slipping under the sterno-costal plastron at the moment of systolic retraction when separation occurs between heart and thoracic wall, and this, because the thoracic wall was flexible (young patient), accounted for the precordial retraction and the rolling movement found during life. The retraction of the intercostal spaces was due to pleuro-diaphragmatic adhesions, results of pleurisy which the patient had previously had.

It is evident that such complex cases are rarely met with and the fact that they may appear does not detract in the least from the value of radiological examination.

CHAPTER VIII

AORTITIS

IT is common to find on post-mortem examination many different lesions of the aorta which have not been recognized during life. Sometimes considerable dilatations or aneurisms are seen, more often those "middle states" of aortitis, consisting of moderate enlargement of the vessel together with gelatiniform or atheromatous patches on the walls. These types of aortitis may escape observation completely and not be indicated by any perceptible sign on percussion or auscultation. The number of these accidental autopsy findings will diminish with the progress of radiology which already shows the most minute alterations in the shape of the aorta in the incipient stages.

I. THE AORTA IN THE NORMAL

Radioscopic examination of the right aorta should be made in two positions: (1) frontal position, the screen in contact with the sterno-costal wall; (2) oblique position, the patient standing, in profile, three-quarters, etc., behind a fixed screen, parallel to the plane in which the tube moves.

1. Frontal Position. The examination may be made in two ways and the patient observed in the vertical position or in recumbency; it is always necessary to specify which has been used, as the contours of the aorta present, as the case may be, slightly different images.

In general, the tracing shows on the right above D (Fig. 144) a sinuous line reëntrant as far as Ca and appreciably rectilinear from Ca to A. In its first course,

this line marks the superior vena cava; in its second section, it marks the contour of the ascending aorta. This contour rarely goes beyond the sternal shadow in young patients; but in adults it may overlap it slightly without a pathological condition being indicated.

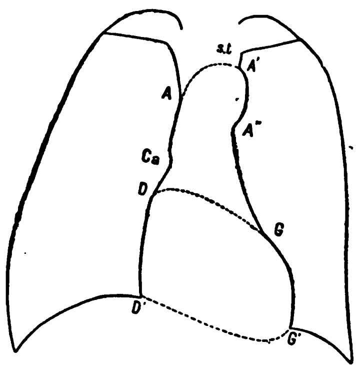

FIG. 144. CONTOUR OF THE AORTA AND THE HEART IN FRONTAL POSITION

The examination of the left side of the patient (right side of Fig. 144) shows that from A′ to A″ is a semicircular contour of especial interest for it represents the projection of the upper descending portion of the aortic arch. In this curved line there are two points to consider: first, the importance of its development which is naturally greater according to the space occupied by the aortic arch, and then, the distance which separates its point of origin from the sterno-clavicular articulation (st).

The aortic semicircle is very clear in adults, still more marked in the old; it may be lacking in children and the young. When there is a volumetric alteration in the vessel, it presents a more or less considerable increase and the estimate of it constitutes one of the essential elements of the description of the aorta. This will be considered presently.

The distance which separates point A′, origin of the aortic semicircle, from the stérno-clavicular articulation (st), varies according to the age of the patient and the more or less considerable development of the arch of the aorta. In normal adults the line which marks the left outline of the sternum from the clavicle to point A′ is on the average 2 to 3 centimeters. Its length diminishes in the old, and point A′ may be close to the sterno-clavicular articulation, especially in patients with a short thorax. The upper point of the aortic semicircle never does overlap the line which marks the shadow of the left clavicle unless aneurism of the aortic arch is present.

The preceding figure is much modified according to the position of the body and by successive respiratory acts.

In the vertical position, the pericardial sac and its contents draw the vessels at the base to the medial line and cause them to undergo a certain elongation; the image of the aorta is then attenuated and elongated. In dorsal recumbency, on the contrary, the heart is pushed up and the aortic arch is broadened (Fig. 145).

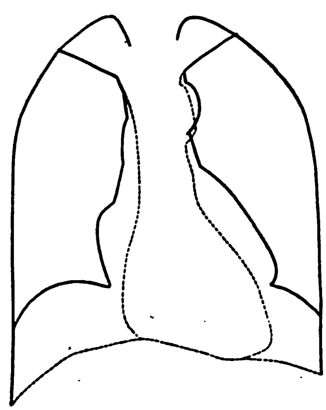

FIG. 145

Black lines, projection in recumbent position; dotted lines, standing position.

Respiration causes the same modifications. The arch is lowered, elongated and seems to contract in inspiration; in expiration it rises, broadens out, and its transverse diameter is increased. These modifications, which are as a rule purely physiological, might, if they were not known, lead to erroneous interpretations. It is important, therefore, to compare with each other tracings taken only in identical positions and in shallow respiration.

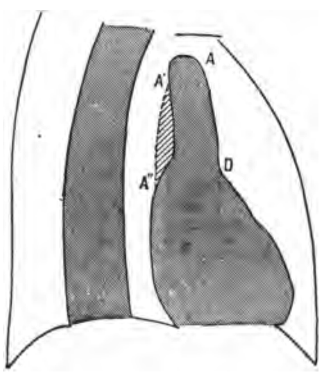

FIG. 146. RIGHT ANTERIOR OBLIQUE POSITION AT 45 DEGREES

2. OBLIQUE POSITION. Examinations in the oblique position are conveniently made in the vertical position only, which allows the body to be in the required obliquity and so to dissociate the vascular shadows from the shadow of the vertebral column.

The *right anterior oblique position* is the most favorable for the examination of the ascending aorta. It is obtained by holding the patient's right shoulder in contact with the screen, the bi-scapular axis forming with the plane of the screen an angle of varying degree.

Between 40 and 45 degrees the image shown in Fig. 146 is obtained. Above the shadow of the heart another shadow will be noticed stretching to the right, digitiform, with parallel contours, which rises almost vertically to

the region of the clavicle. The border AD is sharply silhouetted on the clear field of the left lung and marks the outside of the ascending portion of the aortic arch. The inner outline joins a penumbra A′A″ which begins toward the superior part of the aortic contour and grows larger as it descends toward the auricular shadow. This penumbra is due to the projection of the descending portion of the arch and is less dense than the first because the vessel is on the left of the patient and consequently farther from the screen. Between the projection of the descending aorta and that of the vertebral column is a

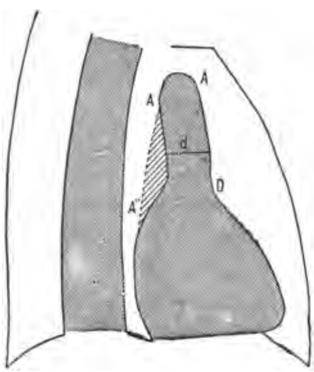

FIG. 147

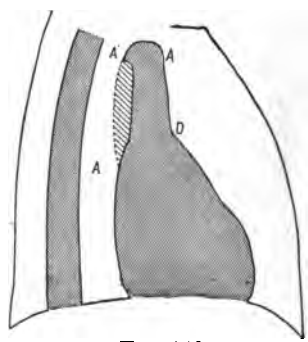

FIG. 148

FIG. 147. RIGHT ANTERIOR OBLIQUE POSITION AT 50 DEGREES

FIG. 148. ANTERIOR OBLIQUE POSITION AT 60 DEGREES

clear band of unequal size which descends to the level of the dome of the diaphragm; it is known as the retrocardiac clear space.

A greater obliquity, 50 degrees, for example, accentuates the shadow of the descending aorta, which begins at a higher point (Fig. 147).

The image obtained with an obliquity of 60 degrees is one of the most instructive (Fig. 148). The gray shadow of the descending aorta occupies a still more important

place in the retro-cardiac space. Its strongly convex outline stands out clearly from the shadow of the ascending aorta, with its rectilinear outlines. Here the top of the arch presents a new appearance; it seems to enlarge in the form of a beak which is turned toward the vertebral column and gives a dense shadow; this is the foreshortened projection of the horizontal portion of the arch.

The aortic shadow in oblique position is one of the most interesting to examine closely; if it is uniformly enlarged in the form of a club, it can be concluded that there is a fusiform dilatation of the vessel; if it shows in pointed form a sac, superadded but dependent on the aorta, it may be concluded that an aneurismal sac exists; if it is only more sinuous, with contours denser than usual, this alteration of the image is probably due only to marked modifications in the disposition and the anatomic structure of the vessel.

Examination in the other oblique positions does not give this same information. However, in left anterior oblique position, above the distention of the pulmonary artery a portion of the ascending aorta is observed, the shadow of which is not covered by the penumbra of the descending aorta; at a proper angle, the contour of its outlines is clearly seen; it is also easy to measure the deviation and to check the figure of the diameter obtained with that found in right anterior oblique position.

3. Nature of the Information Obtained. Orthodiagraphic examination gives a projection of the vessel which is not deformed; *quantitative* or rather *volumetric* information is obtained by measuring its different elements.

Fluoroscopic examination will have shown the more or less marked flexuosity of the vessel, the amplitude of its pulsations, the transparency or the opacity of its walls, all indications which are, so to speak, *qualitative*.

A. *Volumetric analysis. Three dimensions method.* In order to have as exact an idea as possible of the dimen-

sions of the thoracic aorta, it is necessary to make on each one of the two orthodiagrams, one in the frontal, the other in the right anterior oblique position, measurements in the regions determined on, before making fixed marks on the skin.

The right anterior oblique tracing (Fig. 147) gives the image of the ascending aorta in the standing position. A horizontal line drawn from one to the other of the parallels which delimit the artery in its middle portion, gives the measure of their distance apart (line *d*). The caliber of the vessel in its ascending course will thus have been established. That is the first fixed mark.

On the tracing in the frontal position, two other bearings are taken: the first corresponds to the transverse diameter of the arch, the second to the chord which subtends the left aortic semicircle.

The transverse diameter of the arch is represented by the maximal distance which separates the contours of the aortic shadow on the right and left of the sternum. The two most salient points, not being at the same height, cannot be joined by a horizontal line. So the two greatest semi-diameters are taken terminating in the mediosternal line (lines *t* and *t′* of Fig. 149), and together they give the measure of the transverse diameter. In recumbent position this diameter exceeds by about five millimeters that in the vertical position.

The measure of the chord which subtends the left aortic semicircle gives good practical indications (line A′A″ Fig. 150). This chord is thus defined: above, the point where the convex line which marks the arch issues from the mediastinal shadow and begins its outline on the left pulmonary field; below, the point of intersection of the semicircle with the contour of the pulmonary artery (point A″).

Anatomically, this measurement is open to criticism, and, moreover, it corresponds to only a part of the descending aorta; it presents, according to the age of the

patient, a remarkable constancy. But in order that it should have its full value it is necessary that the variations should not be assignable to any extrinsic cause, for example to a pushing back toward the left of the mediastinal organs, caused by a tumor, an effusion, or adhesions.

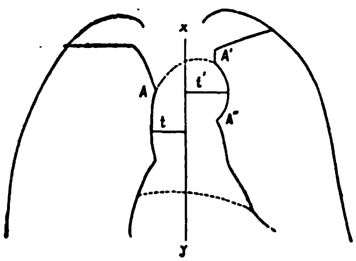

FIG. 149

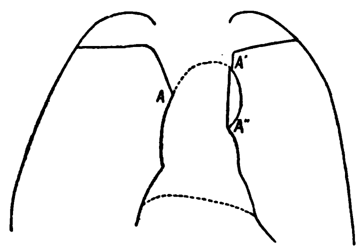

FIG. 150

FIG. 149

The lines t and t' represent the two transverse semi-diameters.

FIG. 150

Line A′A″ is the chord which subtends the left aortic semicircle.

It may be noted that the chord of the left aortic semicircle varies in length according to the position of the patient. In a general way, up to about the age of forty years, it is 3 to 5 millimeters longer in the standing than in the recumbent position.

To summarize, therefore, the volumetric analysis of the aorta depends on the evaluation of three points of measurement which have just been studied.

From a large number of healthy patients, the figures corresponding to these three dimensions have been taken and are presented in the following table:

TABLE OF THREE DIMENSIONS

NORMAL SUBJECTS. MEN. STANDING POSITION

Age	*Transverse diameter in cm.*	*Chord of aortic arch in cm.*	*Diameter of ascending aorta in cm.*
16 to 20 years	4 to 5	0 to 2.5	1.5 to 2
20 to 30 years	5	2.5	2
30 to 40 years	5 to 6	2.5 to 3.3	2 to 2.5
40 to 50 years	5.5 to 7	2.8 to 3.5	2.5 to 2.8
50 to 60 years	6 to 7	3 to 3.7	2.5 to 3
Over 60 years	6 to 8	3 to 4	3

In women the figures are generally somewhat lower.

It is hardly necessary to take account of the stature and weight of the patient, which give only slightly appreciable differences; however, a man with well-developed muscles will usually show the extreme dimensions indicated in the table.

With these reservations, it is evident that the age of the patient is the most important factor in the variations of these measurements; that is the conclusion recently arrived at by a Japanese writer, Iwakichi Kam.[41] He has examined systematically the caliber of the large arteries of the body, on post-mortem, and has shown that the circumference of the aorta increases progessively from birth to the most advanced age, its caliber being greater at the same age in man than in woman.

The figures which have just been given, though they are only relative, nevertheless constitute a practical guide in estimating the volume of the aorta. Though their relations cannot be expressed by mathematical constants, yet by analyzing them carefully important deductions may be drawn for the diagnosis of the existence and the variations of aortic dilatations, however slight they may be.

[41] Iwakichi Kam, *Virchow's Archiv, für pathol. Anat.*, Bd. CCI, 1910.

An increase in the three diameters indicates that the aorta is enlarged equally in all parts.

A predominant increase of the transverse diameter, that of the ascending aorta being normal and the chord slightly developed, ought to lead to the conclusion that the aorta broadens under the costal plastron, the arch describing a curve of large radius.

A greater increase of the length of the chord than of the two other dimensions without elevation of the top of the arch means only, if it is assumed that there is no aneurism, an enlargement of the aorta, very low and due to thoracic aortitis.

Finally, a marked enlargement of the chord and transverse diameter with elevation of the top of the arch, the caliber of the vessel remaining normal, indicates a very sinuous and elongated aorta.

B. *Qualitative analysis.* Radioscopy furnishes indications concerning the state of the arterial walls, based on the study of the *aortic pulsations, density of the shadow, appearance of the contour,* and on the *height of the arch.*

(a) *Aortic pulsations.* In general, the pulsations of the aorta are distinct and of moderate expansion. Perceptible at the level of the left aortic semicircle and along the right outline of the ascending aorta, they become feeble pulsations or localized undulations at the level of the wall, or, again, more extended oscillations, displacing rhythmically the entire arch at each systole. This latter phenomenon is found especially in patients over sixty years old, and only when the elasticity of the arterial *tunicæ* is diminished. In atheromatous patients or in the course of aortitis with thickening of the walls, the pulsations become barely perceptible or disappear. In other cases, on the contrary, the pulsations are greatly increased in amplitude, and especially in young patients this may occur without any organic lesion.

(b) *Density of the aortic shadow.* The density of the

shadow cast by the aorta should be observed carefully in the course of radioscopic examination; it may vary more or less according to the condition of the arterial walls.

In a normal subject the appearance of the overlying portions of the shadow is modified according to the age. In the adult and adolescent this shadow is plainly gray, but the contour is very visible and sharply outlined against the transparency of the lungs. Its opacity is always less than that of the shadow of the left ventricle. In the aged the density is greater and approaches that of the cardiac shadow.

In the pathological state, the density of the aorta may be as great as that of the heart, sometimes even greater. Sometimes the opacity of the vessel affects the whole image of the aorta; sometimes it appears as spots and patches, irregularly distributed over the surface. When these spots are clearly perceptible in the intercostal spaces they correspond to calcareous plaques. On the other hand, in certain cases usually accompanied with dilatation, the shadow becomes extremely light, as compared with the cardiac shadow.

Finally, it may happen that the aortic shadow retains its normal density, even though the vessel may present evident signs of enlargement.

The density of the shadow, then, has no direct relation to the volume of the vessel, nor, consequently, to the amount of blood in it. It is the condition of the walls, their thickness, and especially the presence of calcareous plaques which greatly accentuate the opacity of the shadow, as has been proven by examining anatomical material.

The density of the shadow can also be studied in oblique position.

In the adult the shadow of the ascending aorta and the penumbra of the descending aorta are sometimes difficult to dissociate. At forty, and especially over sixty years

of age, the ascending portion is much denser and cuts into the clearer shadow of the descending portion. This contrast of densities is even more marked in case of an atheromatous artery.

(c) *Contours.* The shadows of the aorta are interesting to observe in the frontal and oblique positions. The portions which overlap the median shadow have, in the frontal position, a curvilinear contour with no irregularities; the left salient is bounded by a circular arc. In the pathological state these contours, independent of their enlargement, show in certain cases abrupt angles or appreciable sinuosities.

In the right anterior oblique position, the lines of the image of the ascending aorta were seen to be parallel and most often rectilinear. In the pathological state these may show unequal curves which describe perfectly characteristic sinuosities. The top of the arch sometimes shows a certain degree of distention.

Finally, when the thoracic aorta is dilated or simply sinuous, the descending portion is outlined, in the oblique position, by a more or less irregular curve somewhat near the vertebral shadow.

(d) *Height of the arch.* It has been indicated above how to estimate in the frontal position the height of the arch and its variations in the normal. This height increases in certain types of aortitis. This indication will be verified by examination in the oblique position, by noting the position of the transverse aorta in relation to the clavicle, the patient standing with arms hanging down.

It may be said, therefore, that the general condition of the aorta, as determined by radiological examination, is represented by two series of parallel analysis:

1. Volumetric analysis depending on the three dimensions method:

The transverse diameter of the arch;

The chord of the left aortic semicircle;

The diameter of the ascending aorta.

This analysis gives the real dimensions of the aortic shadow.

2. Qualitative analysis which furnishes important information on the density of the arterial walls, their more or less great elasticity, the elongation, the spreading of the arch, the rigidity or flexuosity of the outlines.

These data will be applied to the study of the pathological aorta.

II. THE AORTA IN THE PATHOLOGICAL STATE

Clinical observation gives two sets of facts which are very unlike but in each of which the aid of radioscopic and orthodiagraphic examination is indispensable.

The first category of cases concerns patients who, whether or not complaining of subjective disturbances which may be properly ascribed to a lesion of the aorta, nevertheless have such a lesion, as objective examination proves.

The second category includes patients who have identical disturbances logically ascribed to an analogous affection which, however, cannot be confirmed by any of the methods ordinarily used.

A. *Case in which the diagnosis of aortitis is evident after objective examination.* The subjective disturbances which point to an alteration in the aorta consist ordinarily of dyspnœa on exertion, of permanent or paroxysmal oppression, in the form of asthma or pulmonary œdema and in the pains which frequently accompany angina pectoris.

The objective signs which give the cause of these disturbances are furnished by percussion and auscultation.

The auscultatory findings are often doubtful; sometimes altogether negative. Sometimes only a systolic or diastolic murmur or a double murmur at the base of the heart is obtained; but that means only that the lesion has extended to the aortic valves. These murmurs may be

lacking even when the diagnosis of aortitis is, for other reasons, quite evident; they may exist without any alteration in the vessel beyond the valvular area. Often the pathological sounds are reduced to a metallic sound or to an accentuation of the second aortic sound.

The resources of palpation and percussion are more valuable; they consist in the determination of three signs which may exist together or singly: a superelevation of the right subclavian artery above the clavicle, a salience of the aortic dome in the sternal notch and an overlapping of the dullness of the aorta on the right side of the sternum at the level of the first intercostal spaces. The figure resulting from this latter anomaly represents fairly well the crest of a helmet, whence the name *"matité en casque"* (Potain).

When this sign is present, and especially when it is accompanied by the two other anomalies described above, dilatation of the arch of the aorta can be diagnosed. But if this sign is lacking the conclusion that there is no lesion of the vessel is not justified, because it may be altered in some other part causing the same subjective symptoms.

In cases in which diagnosis of aortitis with dilatation of the arch is made by the combination of subjective disturbances and of signs furnished by direct examination, for example in Hodgson's disease, it might seem therefore that radioscopy would be unnecessary. It is not so, because radioscopy enables the results of palpation and percussion to be checked and completed, which is an appreciable advantage, and the evolution of the lesion to be determined by examinations made at different stages.

Orthodiagraphy has demonstrated the value of percussion: this assertion is true for percussion of the heart, and equally so for percussion of the aorta. In all the cases in which percussion has shown that a dilatation of the vessel at its point of origin existed, orthodiagraphy has confirmed it. One example is given here:

A man forty years of age complains of subjective dis-

turbances which make possible a diagnosis of Hodgson's disease.

Objective examination shows an elevation of the aortic arch above the sternal notch and of the subclavian above the clavicle. Percussion of the aorta shows the existence of a dull area in the form of a helmet.

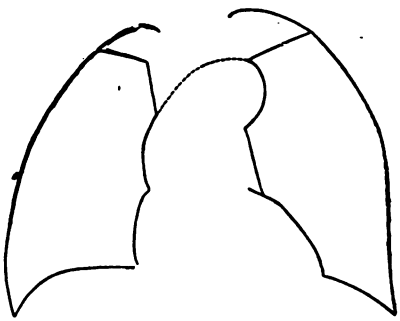

FIG. 151

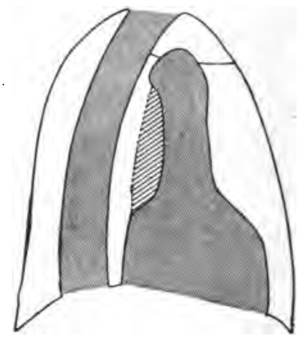

FIG. 152

FIG. 151. AORTA SLIGHTLY ENLARGED, ARCH ELEVATED

FIG. 152. SAME CASE, IN RIGHT ANTERIOR OBLIQUE POSITION AT 50 DEGREES

Orthodiagraphic examination gives the images shown in Figs. 151 and 152 and the description of the aorta may be expressed in the following manner:

Volumetric analysis: three dimensions method:

Transverse diameter = 8 centimeters.

Chord = 4 centimeters.

Diameter of the ascending aorta = 3 centimeters.

Qualitative analysis:

(a) Pulsations very weak.

(b) Dense shadow; ascending aorta distinctly visible.

(c) Contours flexuous, abrupt angles (in frontal position).

(d) Top of the arch elevated.

Conclusion: Aorta slightly enlarged, arch raised, walls thickened.

As will be seen, the radiological indications confirm the percussion findings. The distention of the vessel is affirmed and its exact position determined, at the same time the facts which might escape the ordinary methods of investigation are accurately given, namely, diminution of the elasticity of the arterial walls, their flexuosity and thickening.

If it is sometimes difficult, clinically, to verify the existence of aortic changes, it is still more difficult to judge, some months later, the way in which they have developed. The interpretation of the data furnished by ordinary methods of investigation leads too often only to uncertain results. The interpretation of subjective symptoms is no less deceptive. Prognosis remains often most obscure in cases of aortitis.

Under such circumstances radiology seems most valuable by giving precise information. Two convincing cases are reported here. In the first case orthodiagraphy confirmed the clinical impressions by showing a clear regression of the aortic lesions corroborated by a corresponding amelioration of the subjective symptoms. In the second case, on the contrary, it revealed a progressive aggravation of the lesions of the aorta and thus revised a prognosis which according to the ordinary methods of clinical investigation would not have been considered unfavorable.

The first was a man fifty-eight years of age examined March 6, 1910; he had been suffering for some months from dyspnœa which grew worse after exertion. Several times during exertion he had attacks of frothy and bloody expectoration. Marked increase of arterial pressure, marked increase of the aortic dullness *"matité en casque,"* with an overlapping of about 2 centimeters on the right side of the sternum. The right subclavian was perceptibly above the clavicle. The heart was hypertrophied; the pulsation of the apex was in the lower part of the sixth intercostal space, below the nipple.

In June, 1910, the patient was treated at Royat by Heitz. In July he returned much improved. The subjective symptoms had moderated and percussion indicated a regression of the signs previously found. The apex of the heart had lifted, the area of cardiac dullness had diminished and the aorta only slightly overlapped the right side of the sternum. The resulting favorable impression was confirmed by radioscopy (Fig. 153).

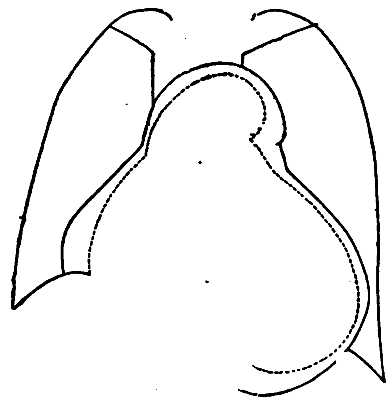

FIG. 153. CASE OF IMPROVEMENT

Black lines, first tracing; dotted lines, tracing after treatment.

An earlier examination, made in May, 1919, furnished the following results:

AORTA. *Volumetric analysis:*

Transverse diameter = 9.5.

Chord = 5.6.

Diameter of ascending aorta = 3.5.

Qualitative analysis:

(a) Pulsations weak.

(b) Shadow rather dense.

(c) Contours parallel.

(d) Top of the arch slightly elevated, about 1 centimeter below the sterno-clavicular articulation in frontal position.

Conclusion: Aorta regularly and notably enlarged and slightly thickened.

HEART much enlarged.

Longitudinal diameter = 20 centimeters.

Horizontal diameter = 22.3 centimeters.

Left ventricular outline markedly convex.

Apex much rounded. Right ventricle descends 4 centimeters below the diaphragm.

In July, 1910, after treatment, the radioscopic description is as follows:

AORTA. *Volumetric analysis:*

Transverse diameter = 7.6 centimeters.

Chord = 4.8 centimeters.

Diameter of the ascending aorta = 3 centimeters.

Top of the arch not so high.

HEART. Longitudinal diameter = 19 centimeters.

Horizontal diameter = 19.9 centimeters.

The right ventricle has decreased in volume and descends only 2 centimeters below the diaphragm.

The improvement is definite, as proved by the clinical examination and radiological findings but considering the precision of the radiological findings, it cannot be regarded as superfluous.

Here, on the other hand, is a case in which the aggravation of the phenomena was distinctly brought out by radioscopy when other methods had failed to establish it.

M. de B., fifty years of age, dyspnœa on exertion for some months, nocturnal oppression and palpitation. Objective examination shows a double aortic lesion with dilatation of the vessel at its point of origin, characterized by dullness "*matité en casque*" and elevation of the right subclavian. The patient was immediately put under treatment. The attacks of oppression decreased and he was able to resume a very active life. A year later, the grave symptoms no longer appeared; the objective signs continued but were not appreciably increased. On orthodiagraphic examination, a most manifest and serious

modification in the condition of the heart and aorta was found.

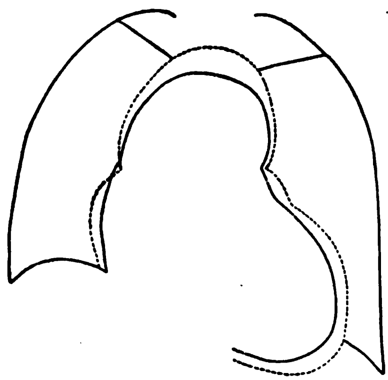

FIG. 154. CASE OF AGGRAVATION
Black lines, first tracing; dotted lines, second tracing.

The tracings (Fig. 154) show this. The dimensions of the heart and aorta are appreciably increased. The aortic arch shows increased transverse diameter and chord and a decidedly elevated top. The longitudinal diameter of the heart has increased from 18.4 cm. to 19.7 cm., and the horizontal diameter from 17.5 cm. to 19.5 cm.

Radiological examination was found to be correct as against clinical examination, the prognosis was therefore much more alarming than had been supposed. Some months later the patient was seized with an attack of acute aortitis with cardiac and aortic distention and succumbed immediately in full asystolism.

B. *Cases in which the subjective symptoms of aortitis are not accompanied by any objective sign.* It occurs frequently that the diagnosis of aortitis ought to be suspected, in spite of the absence of definite objective signs, and because of the existence of subjective disturbances which are sufficiently characteristic to warrant it. Cases of this kind include acute and chronic progressive aortitis. Examples are presented here:

A patient forty-eight years of age returned home in the morning after a fatiguing night. At the moment of retiring he was suddenly seized with severe pain in the retro-sternal region, extending toward the back between the shoulder blades with irradiations to the shoulders, especially the left and even to the jaws. The face was pale and drawn, respiration rapid and shallow. The pain lasted several hours, accompanied by fine râles in the chest, then it diminished progressively to reappear for a short time the next day, leaving behind a sensation of extreme prostration.

From the combination of these symptoms, a diagnosis of acute aortitis with angina pectoris was made. The objective examination, however, gave no other indication. The arterial tension was normal. Percussion and auscultation were negative.

Some days later radioscopic examination (Figs. 155 and 156) left no doubt of the existence of lesions which had only been suspected.

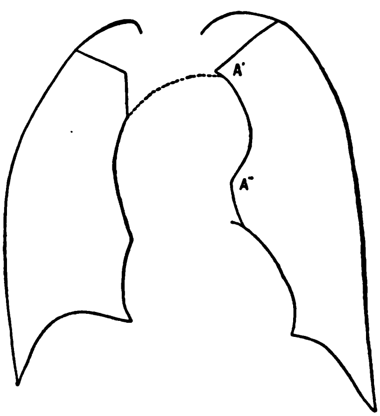

Fig. 155

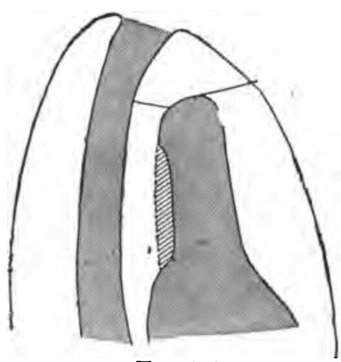

Fig. 156

Fig. 155. ACUTE AORTITIS

Fig. 156. SAME CASE, IN RIGHT ANTERIOR OBLIQUE POSITION AT 50 DEGREES

The detailed description of the aorta is as follows:

AORTA. *Volumetric analysis:*

Transverse diameter = 9.8 centimeters.

Chord = 5 centimeters.

Ascending aorta = 4 centimeters.

Qualitative analysis:

(a) Pulsations imperceptible.

(b) Shadow rather dense in oblique position.

(c) Contours parallel.

(d) Top of the arch slightly elevated.

Conclusions: Aorta uniformly enlarged in rather marked proportions; the top of the arch is not elevated, but the vessel appears rather dilated below; the walls are thickened.

Cases of acute aortitis of this kind are far from exceptional; we have met several similar cases in which radioscopic examination showed alterations which had not been found by the ordinary methods of investigation. The same thing may occur in chronic aortitis. The following case bears this out.

M. X., fifty-eight years of age, for six months previous had had typical attacks of angina pectoris. These occurred especially after eating and during rapid walking. They began in the epigastrium, then moved upward behind the sternum and finally localized over the chest causing the usual shooting pains. For some months the attacks had become especially painful.

The obvious clinical diagnosis was angina pectoris due to aortitis or rather angina in its gastralgic form (*angina abdominis*); this diagnosis, however, depended exclusively on subjective symptoms, for objective examination, by percussion and auscultation, did not reveal any appreciable modification of the aorta.

The result of radiological examination was quite different (Figs. 157 and 158). It showed that a very marked alteration of the vessel existed since the transverse diameter measured 9.9 cm., the chord, 5 cm.; the diameter of

the ascending aorta was almost double the normal. The shadow of the vessel was *very light.* The top of the aortic arch was not much elevated, which explained the negative results of percussion and palpation. On the contrary the dilatation of the vessel was very slight, as was proved by elongation of the chord, and by the results of oblique examination of the aorta. In gastralgic or abdominal angina, this has been previously observed.

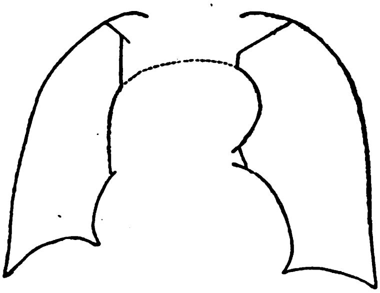

FIG. 157

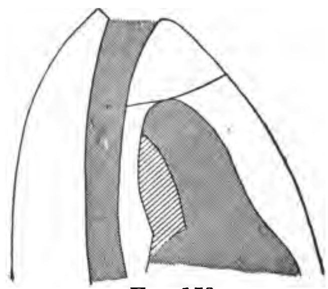

FIG. 158

FIG. 157. CHRONIC AORTITIS

FIG. 158. SAME CASE, IN RIGHT ANTERIOR OBLIQUE POSITION AT 50 DEGREES

Such conflicting results from the different methods of examination are easily explained. Percussion and palpation can determine only the existence of a dilatation of the aortic arch, for that is all that gives perceptible signs; namely, the overlapping of the vessel on the right of the sternum as a result of the exaggeration of the curve of the arch, the elevation of the top of the aorta in the sternal notch, and the elevation of the subclavian above the right clavicle. These modifications are peculiar to Hodgson's disease and that is why this disease rarely escapes detection. The other types of dilatation are naturally not apparent by percussion and palpation. It is not the same with radiological examination which can, as the preceding case shows, give valuable evidence, even in

cases in which the dilatation is located in another part of the vessel.

There are, however, types of aortitis which are not accompanied by any modification of the quantitative or volumetric aortic signs; for this reason such types of aortitis do not cause deformations perceptible by fluoroscopy. Nevertheless, in an indirect manner, these types of aortitis can be determined by changes in the qualitative characteristics in the shadow of the vessel.

Ordinarily these cases are shown on the tracings in the direct position. The transverse diameter is slightly increased, the salience of the left semicircle projects rather high under the left clavicle, as a result of the elongation and the tortuosity of the vessel. But in the oblique position its caliber maintains its normal dimensions. The conclusion can then be drawn, that there is no notable alteration. In spite of this, the diagnosis of aortitis should nevertheless be made when there is opacity of the vascular shadow coincident, fairly often, with spots and dense patches due to areas of calcareous infiltration, and the more or less complete absence of vascular pulsations, indicating thickening and rigidity of the walls of the artery. We have seen several cases of this kind.

The essential subjective phenomenon which characterizes them consists in more or less violent pain, in the form of angina attacks, intense, repeated and lasting. This type of aortitis usually seems to imply a serious prognosis. It resists treatment, and it is not uncommon to note in the course of radiological examinations made at intervals of several months the progressive invasion of the aorta by sclerosis, the appearance of new opaque spots and the gradual increase in the diameters of the vessel.

These types of aortitis, as a rule, cannot retrogress except when they are due to syphilis. But in that case treatment gives beneficial results. It diminishes the attacks of pain and acts on the lesion itself, for radiological

examination reveals a diminution in the opacity of the arterial walls with progressive reappearance of the pulsations, indicating that the walls of the vessel are resuming their normal elasticity.

The preceding considerations have a considerable importance.

If lesions of the aorta have too often remained, up to the present time, resistant to therapeutic measures, it is because their usual cause is ordinarily misunderstood and the methods of treatment used not very efficacious; finally, intervention was too late, introduced when the alterations were already irremediable.

The situation is different now. We know that syphilis plays an especially important part in the development of aortic lesions; we have in the Wassermann reaction a valuable method of verifying it. On the other hand, the therapeutic resources at our disposal have an efficacy which is no longer open to doubt. The part of the clinician here, as everywhere, is to recognize the lesion as soon as possible after its first appearance, for therapeutic success depends on early diagnosis. Radiology will therefore enable the alterations of the aorta to be demonstrated at a stage in which they were hitherto not recognized. Radiology gives the exact description of the diseased aorta, allows the early recognition of the lesion, and permits us to follow its development; it is the indispensable complement of every clinical investigation and the most reliable means of checking whatever therapeutic measures may be used.

CHAPTER IX

ANEURISMS OF THE THORACIC AORTA

IN the preceding chapter, the study was limited to the more or less extended lesions of the aorta leaving aside aneurismal dilatations which are met with in cases of generalized aortitis but which also develop very often as isolated tumors affecting only a small portion of the vessel. Although it may be somewhat artificial to separate and consider aortitis on the one hand and aneurism on the other, for these changes are frequently due to the same cause, namely, syphilis, nevertheless the particular development of aneurisms justifies a special study of them.

Radiological diagnosis of aneurism of the thoracic aorta is sometimes extremely simple, when the tumor is large and easily detected by fluoroscopy. When the aneurism is but slightly developed and concealed by mediastinal shadows the significance of which must be determined, the diagnosis is more difficult. The following technic seems necessary for a thorough examination.

First, a complete radioscopic inspection of the thorax, which according to Holzknecht should be made in all the positions: direct anterior, direct posterior oblique and above all in right anterior oblique, noting the successive modifications of the shadows in changing from one to the other of these positions.

The combination of these movements aims to make visible the different appearances of the aorta, to determine whether its contours are regular or not and to estimate the degree of density. In order to carry out these procedures and to have an exact record of the out-

lines of the vessel, it is necessary to vary the angle of the rays and to bring the normal ray tangent to the entire extent of the artery outlines.

After the examination on the screen, an orthodiagraphic tracing in the selective positions is taken as indicated by the preliminary radioscopic steps.

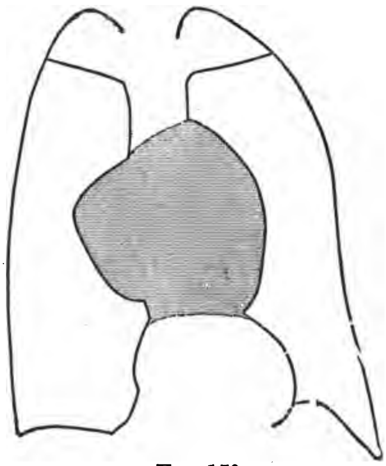

FIG. 159

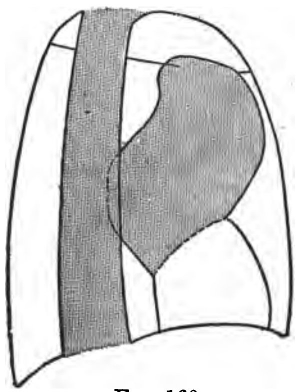

FIG. 160

FIG. 159. ANEURISM OF THE AORTA. HOURGLASS FORM

FIG. 160. SAME CASE, IN RIGHT ANTERIOR OBLIQUE POSITION

I. GENERAL ASPECT OF ANEURISMAL SHADOWS

A description of the different images of large aneurisms will be given, those easily demonstrated by x-rays, in order to deduce the symptomatic characteristics which enable the more difficult diagnosis of *smaller* and *dissimulated* tumors to be made.

The first case for illustration shows an aneurism visible in all positions like that shown in Figs. 159 and 160. In the frontal position the mediastinal shadow is deformed by an abnormal dense salience overlapping the sternum on the right in the first intercostal spaces, on the left at

the level of the superior arch, and broadening out into both pulmonary fields. The mediastinal shadow appears as though formed of two superimposed globular shadows, in the form of an hourglass, the upper being formed by an aneurismal sac larger than the lower, which represents the heart.

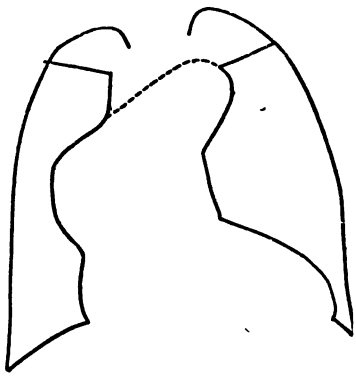

FIG. 161

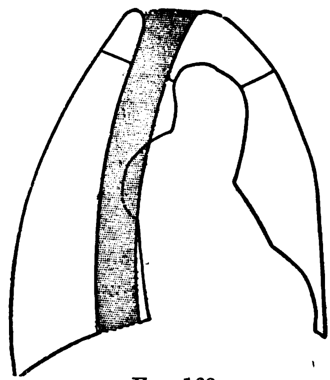

FIG. 162

FIG. 161. ANEURISM OF THE ASCENDING PORTION OF THE AORTA

FIG. 162. SAME CASE, IN RIGHT ANTERIOR OBLIQUE POSITION

In oblique position (Fig. 160), the aortic shadow becomes completely atypical; the parallelism of the vascular contours disappears, the image takes the form of an irregular sac with both anterior and posterior enlargement. The extreme contours invade almost all the anterior clear space; the posterior clear space is filled by the shadow of the sac which at an angle of 50 degrees merges with the image of the vertebral column. This case is a question of a large aneurismal dilatation of the ascending and the descending aorta.

This general disposition of the radioscopic shadows is found in all aneurisms that are easily seen; but they are naturally modified in relation to the topographical dis-

position of the sac. The objective aspect varies according as the sac is on the ascending portion, on the top of the arch, or on the descending portion of the vessel. The images obtained under these circumstances are presented here.

Fig. 161 is a woman forty-seven years of age with a large aneurism of the ascending portion of the aorta, especially at its origin. The aortic shadow in the right pulmonary field forms a very sharp angular salience. The contour is clear and without indentations, and there is no pulsation. In spite of the absence of this latter sign, the diagnosis is none the less positive. The development of the shadow gives evidence of a sac, for the transverse diameter of the arch is 12.7 cm.; moreover, this shadow is dense and homogeneous. In the left pulmonary field, the aortic arc is greater in height than in depth; the chord of the arc measures 5.6 cm. The contours of the left semicircle are irregular but sharp and they pulsate synchronously with the pulse.

If the patient is placed in the right anterior oblique position at about 45 degrees, the resulting image is that shown in Fig. 162. The top of the aorta, somewhat dilated, extends beyond the clavicle; lower, its shadow extends far to the right of the patient and obscuring the retro-cardiac clear space it merges with the shadow of the vertebral column. This abnormal salience is due to the angle made by the aneurism in the frontal position. When the patient is placed in the right anterior oblique position, the mediastinal shadow is thrown entirely to the left, except the much distended sac to the right and toward the back which still remains partly in the right plane of the projection.

This combination of data gives a diagnosis of an aneurism of the aorta, the greatest dimensions of which correspond to the ascending part of the vessel. Here the sac is developed not only outward but also toward the depth of the thorax.

Figs. 163 and 164 are of a woman forty-six years of age with two dilatations, one at the top of the arch and the other of the descending aorta. It will be noted that this latter does not appear in the oblique position, which leads to the conclusion that it is not large; on the contrary, the sac at the top is shown completely.

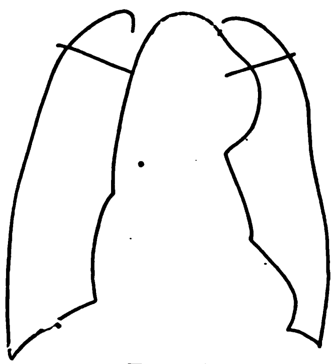

Fig. 163

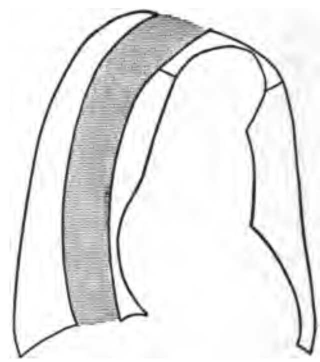

Fig. 164

Fig. 163. ANEURISM OF THE TOP OF THE ARCH AND OF THE DESCENDING AORTA

Fig. 164. SAME CASE, IN RIGHT ANTERIOR OBLIQUE POSITION

An example of the image formed by an aneurism of the descending portion of the aorta is shown in Figs. 165 and 166.

In the anterior direct position (Fig. 165), it is the left aortic semicircle, otherwise called the superior arc, which is abnormally enlarged; the chord which subtends it measures 8.4 cm., and the transverse aortic diameter has the same length.

In the right anterior oblique position (Fig. 166), the exterior contour of the ascending aorta which is compressed toward the outline of the thorax is traced first to the right, then the line curves in at the top of the arch and begins to descend. But presently it rises, goes toward the vertebral column and circumscribes in the

retro-cardiac clear space an irregular shadow which indicates an aneurism. This shadow is not very dense and its contours are rather light owing to the fact that the descending aorta is naturally distant from the plane of the screen.

Only typical images have been presented here in which radiological examination has simply confirmed the clinical diagnosis, at the same time that the details of the lesion were more clearly noted. There are other cases, however, which are especially interesting, in which less developed aneurisms might escape clinical and even radiological examination if it were not made with an exact and appropriate method. This method depends on the analysis of special details which should be understood thoroughly and which consist above all in the *abnormal topographical disposition* of the observed shadow, the *atypical character of the aortic contours,* their *clearness in examination on the screen* and their *pulsations.* It is the combination of these details which has enabled us, in the cases which are to be recorded, to arrive at a final diagnosis later confirmed by post-mortem.

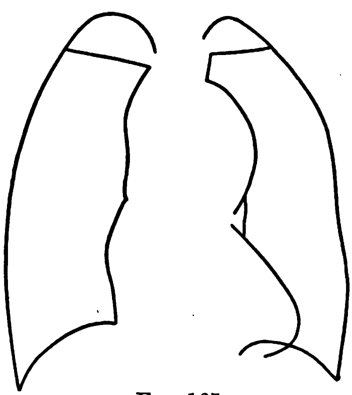

FIG. 165

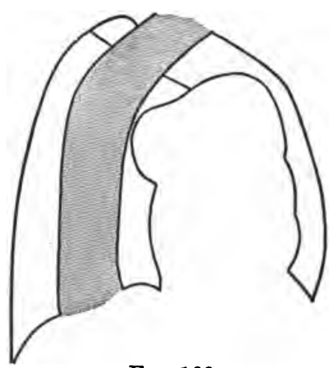

FIG. 166

FIG. 165. ANEURISM OF THE DESCENDING PORTION OF THE ARCH OF THE AORTA

FIG. 166. SAME CASE, IN RIGHT ANTERIOR OBLIQUE POSITION

Fig. 167 is not at all comparable to those that have just been described. The marked characteristic malformations are not found in this case. In the frontal position, the aortic shadow overlaps only slightly, on both sides, the mediastinal shadow in the subclavian region. On the left it projects normally in the first intercostal space, forming an arc slightly exaggerated but not excessive.

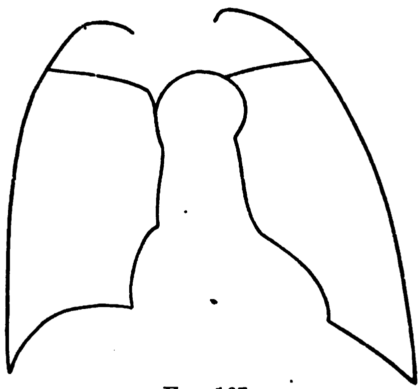

Fig. 167

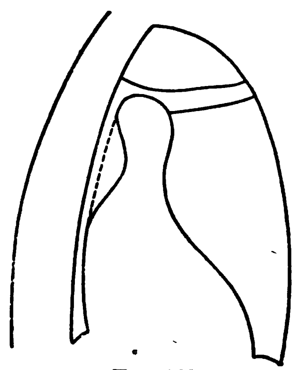

Fig. 168

Fig. 167. ANEURISM OF THE TRANSVERSE PORTION OF THE ARCH

Fig. 168. SAME CASE, IN RIGHT ANTERIOR OBLIQUE POSITION

Also on the right, the protrusion is not considerable, but its position is quite abnormal; it is situated very high under the right clavicle; this can be due only to the presence of a sac. If it were a question of aortitis, that is to say, a cylindrical dilatation of the vessel, the salience of the arterial shadow would show itself, in the right field, much nearer the cardio-vascular angle than the sterno-clavicular articulation. Here it is quite the contrary. Besides, if there were any doubt about it, that would be removed by the fact shown in Fig. 167, that the top of the arch is elevated as far as the sternal notch and that notwithstanding the superposition of the vertebral and

sternal shadows, it is sufficiently clear to be indicated by a black line. Finally, at this point exaggerated pulsations of the sac are seen on the screen.

In the oblique position, the diagnosis is still more clear; Fig. 168 shows that the aorta is deformed in the shape of a club. The conclusion to be drawn from these indications is that there is an aneurism of the transverse por-

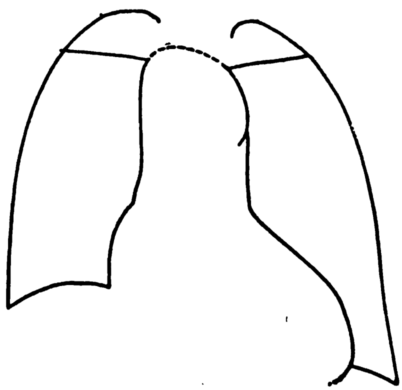

FIG. 169

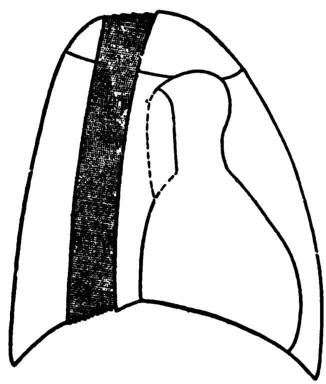

FIG. 170

FIG. 169. ANEURISM OF THE RIGHT CURVE OF THE ARCH

FIG. 170. SAME CASE, IN RIGHT ANTERIOR OBLIQUE POSITION

tion of the arch. The radiological characteristics which justify this conclusion are, principally, as has been indicated above, the anomalous position of the shadow, the atypical aortic contours, their clearness on the screen and their pulsations.

Figs. 169 and 170 show a case of aneurism of the aorta in which the clinical and the radiological diagnosis were still more difficult, based only on a slight development of the sac and its unusual position. Clinically there was found in the first right intercostal space a very slight upward curvature with pulsations giving a thrill on palpation. On the screen the atypical character of the tracing by its clearness was enough to establish a diagnosis. In

Fig. 169 this atypical condition of the outlines showed itself by a bulging of the right aortic contour situated very high near the right clavicle.

In the right anterior oblique position, the caliber of the aorta was enlarged, and moreover, there was a more marked dilatation above and at the right, giving to the top of the aorta a clublike form, the maximum salience of which corresponded to the external thoracic contour. The conclusion then was that there was a uniform dilatation of the aorta and, moreover, an aneurism at the point of the right curve. This diagnosis was definitely confirmed by autopsy.

Sometimes the interpretation of radiological images is still more difficult because the factors of diagnosis appear only in one of the positions, the other furnishing no indication which can be depended on. It is then necessary to remember the rule, which has been insisted on, not to affirm the complete integrity of the vessel under observation until after methodical radiological examination in all positions which it is possible to have the patient take in front of the screen. Here, also, the importance is apparent of adding to radiographic images orthodiagraphic tracings and at the same time the data resulting from fluoroscopic examination, for any one of these methods used alone can lead only to uncertain conclusions.

An example is given in Figs. 171 and 172. The case is of a woman fifty years of age with an enormous presternal pulsating tumor. Now, by examining Fig. 171 there is seen in the frontal position the shadow of the arch overlapping the sternum on both sides in exaggerated proportions but not very considerable. A study of this image would leave no doubt of the importance of the aortic lesion; but in right lateral position (Fig. 172), the general appearance completely changes. An enormous sac is seen which projects across the sternum and exceeds it by 7 cm. If the lack of information on examination in the frontal position in contradiction to the importance of the findings

in the oblique position has only mediocre significance, assuming the certainty of the diagnosis, it is understandable that it is not the same if the tumor is hidden in the mediastinum or if it escapes other methods of examination.

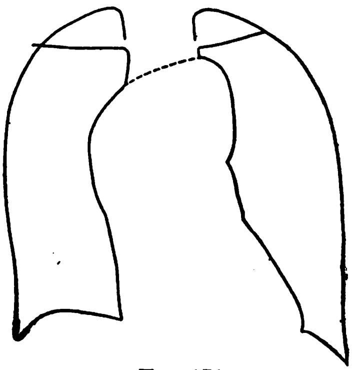

FIG. 171

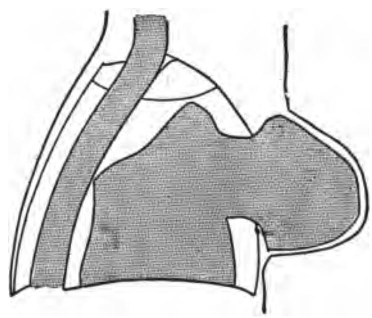

FIG. 172

FIG. 171. LARGE SAC IN THE POSTERIOR-ANTERIOR DIRECTION OF THE ASCENDING PORTION

Few signs in the frontal position.

FIG. 172. SAME CASE, IN RIGHT ANTERIOR OBLIQUE POSITION

This is seen as well in aneurisms of the descending aorta, which often appear only on oblique examination, as in the case of the aneurisms of the antero-superior portion of the arch.

Barjon[42] has described a typical example. Speaking of this type of aneurism he says:

"This aneurism is situated on the median line, behind the sternum, below the sterno-clavicular articulation, at a point where the median shadow is broad and where the normal aorta regularly overlaps it on the left side. Nothing then is visible in frontal examination. If we are

[42] Barjon, *Anévrisms de l'aorte et tumeurs du médiastinum*, Paris Médical, 6 janvier, 1912.

looking, with our minds made up, for an aneurism, we shall easily find it in the oblique position. That happened to me in the case of a patient with paralysis of the left vocal cord which led me to suspect aneurism. There was a regular rounded salience which, overlying the left edge of the aorta, filled the median clear space and touched the vertebral shadow" (Fig. 173).

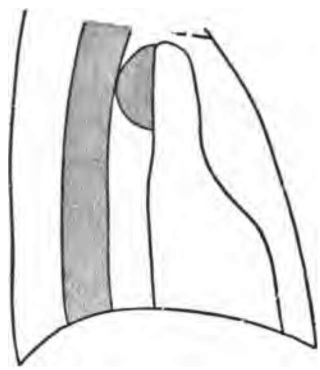

FIG. 173. ANEURISM OF THE ANTERO-SUPERIOR PORTION VISIBLE ONLY IN RIGHT ANTERIOR OBLIQUE POSITION (BARJON)

II. ANALYSIS OF SOME RADIOLOGICAL SIGNS

The study of the particular cases which have been taken as examples, in which there were aneurisms more or less easy to diagnose, has resulted in the recording of a certain number of radiological characteristics which have only been mentioned. A detailed study will be taken up of each of these signaletic characteristics.

(a) *Lack of parallelism of the contours.* The irregularity of the arterial contours is one of the most important signs on which to rely in diagnosing aneurism of the aorta. It is in the oblique position, where the whole length of the aorta is seen and where both outlines of the ascending portion are clearly distinguishable, that we can best observe a modification in the parallelism of the con-

tours. If an aneurismal sac exists, the walls of the vessel diverge in all directions, their projection on a plane being represented by lines irregularly distant from each other, recurved and then decurved to make the ampullary form of aneurism. The resulting images appear immediately quite different from those in other pathological conditions; aortitis, even generalized, increases the caliber of the vessel, but it always keeps its cylindrical aspect; aortic insufficiency accompanied by an arterial lesion likewise deforms the vessel, but the deformation is always situated at its point of origin and presents a regular conic form. On the contrary, the irregularity of the contours observed in a case of aneurism gives at once the impression of vascular hernia or, in a word, of a sac.

In the direct position, the lack of parallelism of the contours is represented by large curves and is distinct from the usual outlines of glands and tumors, which are generally polycyclic and give the shadow an embossed appearance.

(b) *Precision of contours.* The contours of an aneurism are usually clear and linear. There is a striking contrast between their shadow and the clear pulmonary fields. This demarcation is especially evident on radioscopic examination. It is not always the same on radiographic plates, for, as Belot[43] has remarked, a pulsating tumor cannot on account of its pulsations give more than a hazy image on a plate, even if it is taken in a few seconds.

Finally, in the case of aneurism, the curves are rounded and there are no sharp angles, no finger-like prolongations such as are seen in cancerous tumors, no polycyclic contours such as are made by glands. However, these characteristics are not pathognomonic. It may happen that the mediastinal tumors are marked by outlines of perfect clearness simulating arterial walls. On the contrary, there are cases in which the vascular contour is very

[43] Belot, Société de Radiologie, Séance du 12 avril, 1910.

much blurred on radiological examination, when in point of fact there is an aneurism. It is necessary, then, to attribute this fact to the fibrous products of peri-aortitis, sufficiently dense to disturb the clearness of the arterial outline.

(c) *Homogeneity of the shadow.* If we compare the image of an aneurism with that cast by a gland mass, it is noted that the latter presents a shadow of unequal density. It is formed of juxtaposed patches of varying depth. The aortic shadow is most often homogeneous. We say most often, because in some cases of multiple or irregular sacs zones much darker than the rest of the vessel are found. But then these regions correspond to the most enlarged parts of the outline in direct position or to the most marked saliences in oblique position.

(d) *Pulsations.* One of the most important characteristics of aneurism consists in the arterial beats or pulsations which are found on the contour of the shadow. Still it is necessary to look at these very closely and to differentiate the pulsations of the shadow as a whole, which are sometimes only transmitted pulsations, from those of the walls which take the form of an undulation along the contour.

But even if the pulsations are clearly arterial, the conclusion should not be drawn that there is an aneurism; the same image may be given by a tumor of the mediastinum. We have observed two cases of it. In the first the error made by a radiologist and by ourselves was corrected only by the development of the symptoms. In the other it was not recognized until after death, and autopsy revealed an enormous gland mass in the mediastinum. The lateral outlines of the mass were almost parallel and perfectly linear. The aorta passed through the gland mass and it was that which caused the pulsations during life.

It may happen, on the contrary, that the pulsations are lacking on the contour of the aneurisms. Aneurisms

often have been found entirely without movement, either because the sac was filled with an organized clot or because the vascular wall was infiltrated with atheromatous plaques.

To summarize, therefore, if radioscopic examination is useful in diagnosing aneurism of the aorta, it is still, however, open to mistakes. The most perfect radiographic evidence always requires intelligent interpretation.

III. DIAGNOSIS

Although the indications furnished by radiology in the examination of the aorta are numerous and significant, it does not, however, follow that the diagnosis of aneurism is always equally easy. To be sure, it presents no difficulty when the analysis of the tracings and of the radiographic images has enabled the details to be observed which have been noted in the course of this study, if nothing else has intervened to spoil the interpretation. But this is not always the case; in some circumstances the shadows have not the same clearness, or they may be deformed by secondary shadows with irregular contours, having only distant and indirect relations with the aorta, and a minute analysis is then necessary to distinguish what belongs to this vessel and what is due to lesions of the neighboring organs.

The differential diagnosis of aortic aneurism is easily made when the tracings show the presence of an isolated tumor attached to the vessel, having sharp, clearly defined contours, the whole forming an opaque shadow, situated in the mediastinum, with perceptible pulsations on the screen which can be due only to a vascular tumor. These signs are sufficient to eliminate from the diagnosis a whole series of other tumors which may lie in the mediastinum but which do not originate in the aorta: such as lymphosarcomatous tumors at the level of the hilum of the lung; or pulmonary cancers which are situated in the full parenchyma and which also extend some-

times toward the median parts, but in an altogether secondary and accessory manner.

The question, therefore, seems always easy of solution; but it is very necessary that it should present itself under all circumstances with the same simplicity. Aortic aneurism may be complicated with peri-aortitis, with pericardial symphysis, with pleural effusion, all lesions capable of obscuring the regions usually transparent, of obscuring the shadow produced by the aneurism itself, of making the contours diffuse, and therefore making the diagnosis difficult.

Inversely, peribronchial or mediastinal glands, chronic infiltrations or tumors of the pulmonary parenchyma, pleural effusions, mediastinal tumors, etc., when their extent is considerable, may invade all one side of the thorax, from the neck to the diaphragm, and so far obscure the cardio-vascular contours as to make them undecipherable and sometimes mistaken for an aneurism of the aorta which in point of fact does not exist. In these clinical cases, which are so much open to controversy, radiological examination is useful, not, to be sure, in deciding between two doubtful opinions, but in offering elements important in diagnosis.

The first difficulty to surmount is to recognize or, rather, to mark the shadows of the vessels, the second is to dissociate them from superadded abnormal shadows. For that, investigation will have to be made of the different portions of the vessel, and the surface examined, then the outline, varying the angles of incidence. After this examination has verified, on the screen or on the tracings, the exact contours of the aorta, the diameters will be measured; then the entire vessel traced, noting the points at which accessory shadows are superadded. The latter will be marked and often according to their very situation the probable existence of an aneurism of the aorta will be considered. If, in the course of this examination, the aortic outline, at first normal, is suddenly lost in a

superadded mediastinal shadow constituting a real pathological salience of the vessel, the diagnosis of an aneurism will be justified. The conclusion will be different if the shadow presents only accidental relations with the vessel, and a mediastinal tumor is more likely. It will be unusual, then, if in varying the position of the patient there are not found in certain oblique positions, other dense masses of the same form probably as the original mass, which will exclude the idea of aneurism. Such dissociation, made on fluoroscopic as it would be made on post-mortem examination, is often very difficult, but usually if the procedure is methodical a diagnosis is arrived at which, if not final, is at least probable.

A. DIFFERENTIAL DIAGNOSIS OF AORTIC ANEURISM FROM OTHER THORACIC OR INTRA-THORACIC AFFECTIONS

Malformations of the skeleton. The error here is rather exceptional; usually, indeed, clinical examination of the patient shows the presence of such malformations, notably, deviations of the vertebral column.

Pleuro-pulmonary adhesions. Lesions of the pulmonary parenchyma. Very heavy pleural adhesions of the middle region of the thorax rarely lead to confusion because of the irradiated aspect of their contours. They constitute simply a serious interference with methodical examination. Pulmonary infiltrations, which give such extensive shadows in certain cases of pulmonary tuberculosis, are in general rather easily dissociated from abnormal shadows of the aorta.

Cancerous masses, syphilitic gummata, usually have their point of departure at the level of the pulmonary hilum. When they increase in extent, it is only in the form of prolongations either above or outside the clavicle, or more often toward the base of the lung.

Interlobar pleurisy. Right interlobar pleurisy with large effusion often obscures such a great part of the

pulmonary field that it may give the impression of a vast aneurismal sac. But the diagnosis of this form of pleurisy is facilitated by the following signs: the tumor presents a somewhat rounded aspect and its lower contour lies below the region ordinarily occupied by aneurisms. Moreover, it is usual to find a transparent pulmonary band between the tumor and the diaphragm; finally, successive examinations will show, according to the evolution of the disease, a more or less rapid increase of the obscure zone, or, on the contrary, its progressive diminution.

If the effusion is only moderate, in the lateral or oblique positions, its shadow is seen isolated in the middle of the transparent pulmonary field and distinct from the mediastinal shadows.

Cysts of the lung. Hydatid cysts lying in the middle or upper portion of the lung may be mistaken for aneurism of the aorta. The same is true of large dermoid cysts in elevated position. In all these cases it is essential to establish accurately the topography of the shadows, their position and their characteristics in repeated examinations, in case of doubt, some days or some weeks apart. These tumors have usually a clearly circular form which differentiates them from aneurisms. Moreover, the modifications in their size are usually more rapid than those of aneurism.

In other cases, however, the diagnosis remains doubtful, and radiology is unable to establish definitely the position and nature of the tumor observed. It is then that laboratory methods should be resorted to. They are especially valuable in cases of hydatid cysts, as shown by Guedini, Weinberg, Parvu, and Laubry.

Tumors of the mediastinum. Thoracic adenitis, lymphoma, sarcoma, lympho-sarcoma often show considerable shadows in the thorax difficult to interpret. Here the data must be applied obtained by the methods used in order to dissociate the vascular shadows, marking the

contours in all positions, and to determine the presence of a secondary tumor, the existence of which will favor the diagnosis.

B. DIFFERENTIAL DIAGNOSIS OF ANEURISM OF THE AORTA FROM DILATATIONS OF OTHER VASCULAR ORGANS

The presence at the base of the heart of sacciform and expansile tumor does not clearly signify that there is aneurism of the aorta. Such tumors may depend either on the pulmonary artery (but that is rarely the seat of aneurisms) or on great dilatations of the conus arteriosus. There have also been described dilatations of the superior vena cava which might be mistaken for an aneurism of the aorta. Dilatation of the left auricle and especially that of the left appendage may also cast shadow saliences like those of aneurismal sacs. Gallavardin has recently reported a case.

Radiological diagnosis of these different sanguine tumors depends on their topographic position; most often it will be easy enough to determine their exact position and, from that, their origin.

C. ASSOCIATION OF ANEURISM WITH OTHER LESIONS

The association of a pleurisy on the left with aortic aneurism is most often encountered; serous effusion then takes place in the large pleural cavity, and may obscure the left contour of the heart as far as the base. However, it seldom rises higher than the third intercostal space. If the aortic sac is much elevated, the contours of it will be seen above the shadow produced by the effusion; if it lies on the descending portion, it will be obscured by the shadow of the effusion which will make it impossible to follow the inferior contour of the aneurism and to estimate the full extent of it. However, even in these cases, there is one sign which persists and which often allows the suspicion of an aneurism: that is, the abnormal devel-

opment of the left superior arch. In these especially doubtful cases, diagnosis is rendered still more difficult by the fact that the indications can only be made use of when obtained in direct position. Indeed, in oblique positions, the pleural fluid obscures the greater part of the retro-cardiac space, so that it is impossible to say whether or not another shadow exists produced by an aneurism.

It is unusual to see gland masses associated with an aneurismal tumor. But these masses will be easily recognized by their position at the level of the hilum, by the appearance of their shadow which is very uneven; they only interfere with the reading of the outline of the vascular walls.

The association of a *cardiac affection* with an aortic aneurism will be easily demonstrated by radiological examination, because of the characteristics peculiar to each of the diseases of the heart, which have been studied in the preceding chapters. Very often the heart shows no modification of volume when the aorta is the seat of a large aneurismal tumor. Fluoroscopic examination or the radiographic image will easily give evidence of this; but in other circumstances it will not be surprising to find an enlargement of the heart coincident with a valvular lesion of the aorta or with other cardiac affections; the study of these associated lesions has only a limited interest.

CHAPTER X

LOCALIZATION OF WAR PROJECTILES IN THE HEART AND PERICARDIUM

WOUNDS of the heart from projectiles are in the majority of cases rapidly fatal. However, it is not unusual to have patients survive with fragments of metal in the cardiac cavities or the pericardium.

According to a review which we have made of medical literature, eight articles have been published of foreign bodies in the heart not extracted: Finzi (1915, 1 case); P. Delbet (February 2, 1916, 1 case); Grandgérard (August 17, 1916, 1 case); Ledoux-Lebard (1916, 1 case); Lobligeois (November 7, 1916, 1 case); Ascoli (January 1, 1917, 1 case); Lyle (1917, 1 case); Gilberti (February, 1917, 1 case).

Thirteen cases in France which were surgically treated have been published: Beaussenat (May, 1915, April, 1916, 2 cases); Vouzelles (November, 1915, 1 case); Couteaud and Bellot (December, 1915, 1 case); Bichat (May, 1916, 1 case); Dujarrier (March, 1917, 1 case); Chauvel and Loiseleur (March, 1917, 1 case); Le Fort (May, 1917, 1 case); Fredet (June, 1917, 1 case); Hallopeau (June, 1917, 1 case); Petit de la Villéon—Juxta-cardiac projectiles (April, 1916, 3 cases). These thirteen surgical interventions resulted in three deaths and ten cures.

Other cases are known, the reports of which have not yet been published. Ledoux-Lebard has examined seven cases of foreign bodies in the cardiac walls, three of which were operated on; three cases of foreign bodies which had penetrated the pericardium, of which two were operated on. Bouchacourt has radiographed three patients with

projectiles which were not removed; the first, a bullet in the apex of the heart, another, a bullet in the heart, and the third a splinter in the pericardium in the immediate vicinity of the posterior wall. Maingot has radiographed a case with a bullet in the left ventricle, extracted by Hartmann, and a foreign body in the heart of a patient of Pauchet's. Finally, we have examined two cases of projectiles not removed, a rifle bullet in the right auricle and a piece of shrapnel in the pericardium.

Complete statistical data cannot be compiled now, especially of cases in which the projectile was not removed. Many radiologists have observed foreign bodies in the heart and pericardium without publishing their observations; on the other hand, due to the frequent transference of the wounded and the frequent examinations made of them, the same patients must have been fluoroscoped by several specialists. Not until after the war will the *Service de Santé* be able to compile correct statistics. Of the thirty-eight cases, however, which have been brought to our attention, nineteen cases had surgical intervention. In half the cases the projectiles caused disturbances which necessitated their removal.

These disturbances consisted in cardiac pains, in attacks of dyspnœa, permanent or an exertion. The auscultatory signs were insignificant or negative. However serious the functional disorders, the clinical symptoms did not warrant a definite diagnosis. Only radiological examination gave positive evidence.

The importance of radio-diagnosis is therefore apparent. But though it is relatively easy to locate a foreign body in a limb, to indicate the depth in relation to a point on the skin, or by a bony prominence, the localization of a projectile in the heart or pericardium meets with serious difficulties. These difficulties can be appreciated by reviewing the unprecise radiological indications which have been published concerning a few patients that have been operated on. To determine the presence of a metal-

lic body in the heart area is not sufficient. The surgeon demands, in order to operate intelligently, that the radiological report shall be full and precise.

In the conference of November 10, 1915, of the Société de Chirurgie, this question was discussed and Quenu laid down the following principles:

1. In all cases in which projectiles are deeply situated in limbs or in an organ, simple radiography is not sufficient, it only gives preliminary information.
2. In such cases, probing for a projectile is not permissible until after localization, and this localization ought to be made by a skilled radiologist.
3. It is desirable that the surgeon should have at his disposal several methods of research, in case one should fail.
4. It is necessary that the search for foreign bodies be made in close collaboration by surgeon and radiologist.

The best method of localization of foreign bodies in the cardiac region will now be considered.

I. LOCATING THE PROJECTILE

The first question is to determine whether a projectile is in the region of the heart, and this is done by making a general radioscopic examination. The pulmonary fields around the median shadow, the cardio-diaphragmatic sinuses, the hila, the vessels of the base and mediastinum, are examined in order to find out first the condition of the regions which surround the heart and to determine whether pulmonary lesions exist and pleural or pericardial effusions. In the latter case, the obscurity caused by fluid prevents a complete investigation or, at least, a conclusion being drawn from the examination, if no projectile shadow can be demonstrated. But if no complication exists, the examination is continued by inspecting the surfaces of the heart in the direct, oblique, and lateral positions.

Shrapnel balls, rifle bullets, or fragments of some size as a rule are readily seen on the screen. It is not so with small metallic bodies. They may not attract attention. In Fredet's case, there were two small fragments, one intra-pulmonary which was noted several times, the other intra-cardiac which was not noticed in the first examination. If a foreign body in the heart is suspected, a long and careful search is sometimes necessary. The rays should be of great penetration. A hard tube with an easily adjustable diaphragm offers great advantages. Moreover, in the course of the examination, the intensity of the ray is varied according to the circumstances. The rays are passed over the entire cardiac area and the least differences in the homogeneity of the shadow is studied; then the rays are moved obliquely in order, if possible, to make them pass the foreign body at its greatest thickness, which accentuates the shadow, while the patient is placed at various angles in order to dissociate the superimposed shadows of the thorax. Sometimes only a slight movement of the tube or of the body is enough to show the fragment distinctly. After that the radiologist does not lose sight of it and is ready to make precise observations.

When the projectile is free in a cavity, its movement renders it indistinct. By radioscopy we can observe its exceedingly rapid movements. Radiography is not satisfactory, for mobile projectiles give extremely vague shadows or leave no trace on the radiogram. However, some radiographers have arrived at excellent results with apparatus operating at one-fiftieth of a second. It is always useful under these circumstances to objectify the projectile by taking a radiogram. This is indispensable in cases where, in spite of clinical opinion, radioscopic examination remains negative. It may then happen that small splinters, not seen on the screen, are fixed on a good radiogram. This test is always necessary in order to draw a conclusion.

If from this examination the evidence is positive, the

next step is to locate the foreign body as exactly as possible.

II. METHODS OF LOCALIZATION

The purpose of localization is to determine the depth at which a projectile lies with relation to a determined point on the skin. If this has been fixed at the place where incision should be made, the surgeon knows in operating at what distance and in what direction he will encounter the foreign body.

The calculation of the depth is obtained by a number of methods which depend, for the most part, on the geometric relations of similar triangles. The construction of these triangles is based on shifting the tube a known distance. The figure of the projections is completed either by means of instruments or by means of drawings, diagrams, or stereoscopic images.

Instrumental methods are represented by the Hirtz compass and others derived from it. During the operation an indicator marks the direction and the depth of the projectile. It is evident that the mobility of the region to be explored causes technical errors and difficulties. The extent of the movements of the thorax and the respiratory displacements of the heart are not the same. If a mark is made on the skin, corresponding to a zone of the maximal oscillations of the foreign body, unexpected modifications of the respiratory rhythm during anesthesia may render it unsafe. In the course of the operation, the drawing up of the heart into the surgical opening changes momentarily all the surrounding relations. So the use of compasses does not seem strictly advisable in surgery of the heart.

But that does not imply that all measurement of depth should be rejected. It is advisable to try it wherever possible. Among the most rapid methods are those of Ropiquet, Haret, Hirtz-Gallot, Aimé, Barjon, Casel, etc. However approximate the indications may be, there will

still remain, however, an interesting element of individual judgment. It has been seen that the index of depth of the left ventricle in normal subjects varied from 7 to 14 millimeters. The tables of calculation show that these indices correspond experimentally to a depth of 10 to 12 centimeters for the portion of the posterior wall tangent to the oblique ray. The double measurement of the depth of the heart and the depth of the projectile, on condition that the latter is not very far from the zone of the apex, determines whether it is in the anterior or in the posterior segment of the organ, that is to say, in the right or in the left ventricle.

The methods of localization are not of interest except when they help to locate the projectile *anatomically*. So it is this particular point of view that the radiologist ought to keep in mind.

III. ANATOMICAL LOCALIZATION

It is a question of finding out whether the projectile is in the pericardium or in the heart and in which cavity of the heart.

PROJECTILES IN THE PERICARDIUM. When the wound is recent, the hemo-pericardium interferes considerably with the examination and it may be impossible to give an opinion. If the amount of the effusion does not make the projectile invisible, the localization, though very difficult, may be conclusive. As a rule, the foreign body, after having penetrated the folds of the pericardium, falls into the bottom of the sac and is seen in the inferior diaphragmatic portion of the shadow. But if, for some special reason, the piece of metal remains in the upper parts, if it is fixed there by adhesions, it is found by signs very much like those of projectiles lodged in the walls of the heart. We have not found observations which enable us to study this question in detail.

When the effusion has been reabsorbed and the pericardial folds have become transparent again, the locali-

zation of the projectile in the inferior part of the sac is easily made. A number of characteristic signs are noted; those that have been found in the course of an observation of this kind are presented here:

A case of a gunner in the first artillery, with a shrapnel shell seen in direct anterior position, on the inferior contour of the right ventricle, at the level of the left outline of the vertebral column (Fig. 174). It lay about half

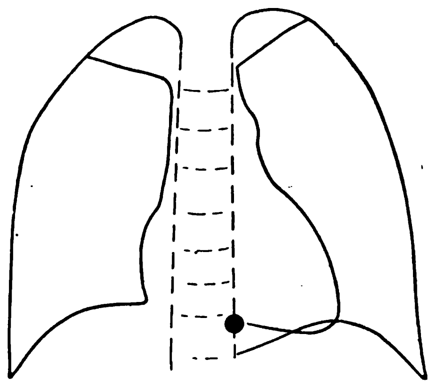

FIG. 174. SHRAPNEL BALL IN THE PERICARDIUM, IN THE LOWER PART OF THE HEART

way over this line. It was separated from the central portion of the diaphragm by a transparent band which enlarged during inspiration. In lateral position, the projectile was under the ventricular mass, 3.5 cm. from the anterior thoracic wall (Fig. 175).

The markings gave the following result: projectile lodged 3.5 cm. deep from the inferior sternal wall, on an antero-posterior line passing to the lower part of the right heart and tangent to the left side of the vertebral column.

A study of the movements of the projectile was made to determine whether the ball was adherent to the ventricular wall or lay in the pericardium.

These movements were of two sorts: (1) pulsations, (2) respiratory displacements.

The pulsations were synchronous with those of the heart, *but they had a much greater amplitude.* They could be studied in right anterior oblique position at 20 degrees (Fig. 176). They spread vertically with a total

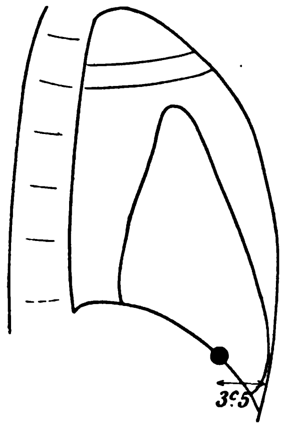

FIG. 175. SAME CASE, IN LEFT LATERAL POSITION

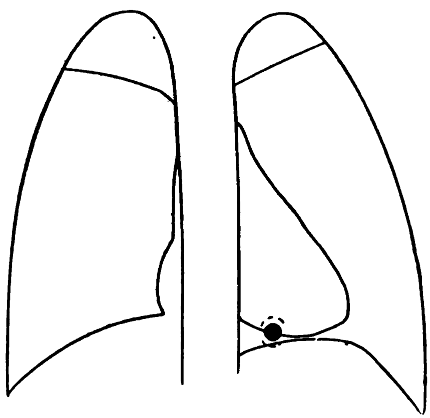

FIG. 176. SAME CASE, IN RIGHT ANTERIOR OBLIQUE POSITION AT 20 DEGREES

excursion of 8 mm., 4 mm. up, and 4 mm. down, which showed that it was a question of transmitted pulsations.

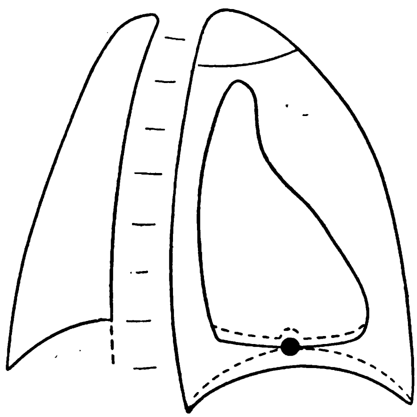

FIG. 177. SAME CASE, IN RIGHT ANTERIOR OBLIQUE POSITION
Respiratory movements of the heart, the diaphragm, and the projectile.

The respiratory displacements indicated in Fig. 177 (right. anterior oblique, 45 degrees), were in the same direction but more extended than those of the heart, also in the same direction but less extended than those of the diaphragm.

The anatomical localization, consequently, was as follows: projectile lodged in the pericardium, in the vicinity of the ventricular wall.

INTRA-CARDIAC PROJECTILES. The cavities most often affected are the right cavities, ventricle and auricle, by reason of the superficial position which they occupy in relation to the anterior surface of the thorax. The left ventricle seems to be less often affected.

To locate a projectile in one of these cavities, it is well to consider successively the *topography* of the region involved and the *movements, pulsations,* or *displacements* of the metallic bodies.

The *topographic indications* furnish data which are

recognized by the projection of the heart shadows in the different positions.

The right ventricle occupies, in the frontal position, the median part of the cardiac shadow, between a rather narrow band along the edge of the left ventricle and a triangular surface with the point down, which belongs to the right auricle. But if the middle zone corresponds in front to the right ventricle, it corresponds behind to the left ventricle. It is not enough, then, to prove the presence of a projectile in this region in order to locate it. It is just

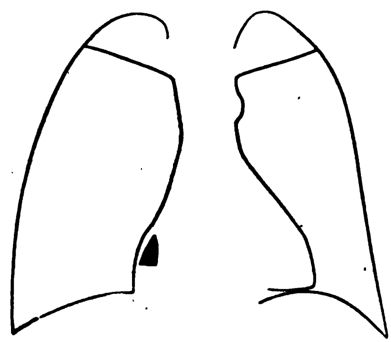

FIG. 178. RIFLE BALL IN THE WALL OF THE RIGHT AURICLE

here that measurement of depth is useful. It is desirable to make this before every intervention, since only operation can verify this question, for the measurements made on the dead body are not comparable with the relations in the living body. In the case reported by Chauvel and Loiseleur, the rifle ball had been plotted 6.5 cm. in depth, rather near the apex. Radiological localization supposed the projectile encysted in the right side of the heart. In point of fact, that is where the surgeon found it.

A manipulation which may show which ventricle is affected consists in placing the patient in left anterior oblique position so that the normal ray passes through the major axis of the heart. An intense illumination

allows us to see the foreign body, and according as it occupies the anterior or the posterior segment, to plot approximately its position.

The right auricle is outlined in the right hemithorax and we may consider as properly belonging to it the area defined on the outside by the right outline of the heart as far as the diaphragm, and on the inside by a schematic line from the cardio-hepatic angle to the median part of the base of the organ.

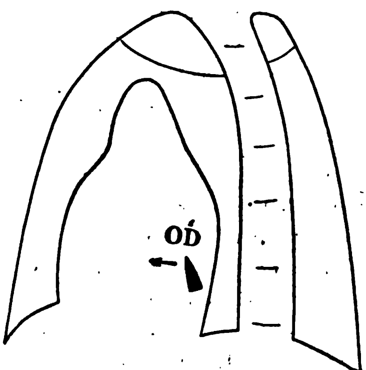

FIG. 179

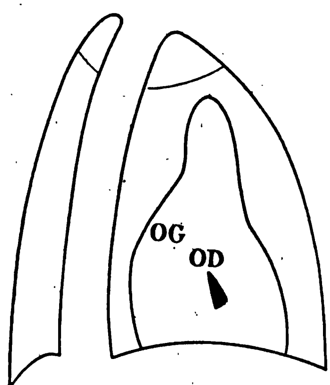

FIG. 180

FIG. 179. SAME CASE, IN LEFT POSTERIOR OBLIQUE POSITION

FIG. 180. SAME CASE, IN RIGHT POSTERIOR OBLIQUE POSITION

It is in this region that projectiles in this cavity are seen. Fig 178 is an example; it is of a patient with a rifle ball in the wall of the right auricle. In left posterior oblique position, the right auricle is outlined in the lower two-thirds of the retro-cardiac clear space (Fig. 179); in right posterior oblique position this auricle corresponds to the median portion of the image of the heart.

It is, in point of fact, in this region that we find the ball (Fig. 180).

Projectiles are animated by variable movements ac-

cording as they are free in the cavities or imbedded in the walls.

In the first case, they show *whirling movements* which are absolutely characteristic. Lobligeois describes these movements in a patient he examined. It was a question of a shrapnel ball lodged in the left ventricle. "At the end of diastole, the ball rested on the inferior border of the heart, near the apex; when systole intervened, it veered rapidly from left to right (of the patient) along the lower border, evidently struck against the interventricular partition and followed that from below upward in vertical direction. It thus arrived at the most elevated point of the ventricle, but against the right side of the ventricle. That was the end of the systole. It remained there an instant immobile, then redescended slowly, from above downward and from right to left, during diastole to resume, after that, the position near the apex of the heart and begin again a new evolution. It described, then, a right angle triangle in which the right angle might have been a little rounded; during the systole it ran rapidly over the two adjacent sides of the right angle and descended slowly during the diastole along the hypotenuse."

Barret has noted in a case with a projectile in the right ventricle whirling movements of extreme rapidity. He compares the agitation of the ball to that of the slug in a sleighbell.

These movements are also observed in the right auricle. In the case of Ledoux-Lebard, the shrapnel ball described continuously a sort of ellipse with a major vertical axis of about two centimeters.

The whirling movements are sometimes intermittent. Ascoli observed a shrapnel ball in the right auricle which described a rhythmic pendular oscillating movement in the transverse direction. Every four or five oscillations there appeared a sudden whirling movement, then the rhythmic movement was resumed. Ascoli noted that the

whirling increased during inspiration, doubtless because of the increase of the intra-thoracic negative pressure which favored the afflux of the blood toward the right auricle.

These movements are considered characteristic of bodies in cavities since the first observation of Trendelenburg. But according to Ascoli they can be observed in cases in which the projectile is lodged in the pericardium. Finally, it should be remembered that not all free intracardiac projectiles are animated by the same movements. In a case noted by Beaussenat a small fragment of shell showed regular movements of slight amplitude synchronous with the beats of the heart; operation, however, showed that it lay in the right ventricle where it was free.

When the foreign body is immobilized against the walls of the heart, its movements are those which it would have if it adhered there closely or if it were enclosed in the myocardium.

These movements are those of the walls of the heart. They consist of *respiratory displacements, static displacements,* and *rhythmic pulsations.*

The *respiratory displacements* lift the projectile at the same time as the organ during expiration and lower it during inspiration. *Static displacements* deviate it one side or the other of the median line during the inclination of the body to the right or to the left.

The *rhythmic pulsations,* synchronous with the pulsations of the heart, offer special characteristics according to the region in which they are observed. Along the left outline they take an almost vertical direction, from above downward, during systole. At the apex, the movement of systolic retraction is from below upward and from without inward, following the longitudinal axis of the heart. At the base of the right ventricle the systolic pulsations go from right to left of the patient in a direction parallel to the inferior outline of the heart. On the anterior surface of the heart (right ventricle) they spread trans-

versally. In the walls of the right auricle the movements of retraction are clearly presystolic and in a transverse direction. Finally, whatever the point is that is examined, the amplitude of the oscillations of the projectile is equal to that of the pulsations of the walls.

The localization of intra-cardiac or pericardiac projectiles necessitates, as will be seen, a series of delicate and often difficult examinations. It may be well to cite here as an example the observation of Digne in the case of Fredet. The radio-diagnosis was as follows: "Fragment the size of a pea, clearly pulsatile, at the base of the left hemithorax, slightly to the left of the median line, intracardiac, situated in the right ventricle probably close against the anterior wall, nearer to the inferior contour than to the longitudinal diameter of the cardiac image." Operation showed that the fragment was enclosed in the wall of the right ventricle two fingerbreadths from the apex and a good fingerbreadth from the inter-ventricular groove.

Radiology, therefore, offers a certain method of investigation, it localizes by radioscopy the exact anatomical position of projectiles and is an essential aid to their surgical removal.

IV. EXTRACTION OF PROJECTILES UNDER FLUOROSCOPIC GUIDANCE

The radioscopic apparatus for the extraction of foreign bodies consists of a base, which supports the tube, placed under a wooden table. The source of the exciting current may be in the operating room, or, if possible, in a neighboring room. Certain surgeons operate by artificial light, red, violet, green, or yellow, which enables them to see at the same time as the roentgenologist the fluoroscopic image of the projectile. The use, which is becoming more and more common, of the "bonnet" fluoroscope, allows the surgeon to operate in daylight; he is guided by the

radiologist who examines intermittently the position of the foreign body.

Intervention under fluoroscopic guidance offers the following advantages:

Before incision, a rapid marking made on the skin of the patient in the operating position indicates the zone in which the surface projection of the foreign body is.

During the search for the projectile, radioscopy gives the surgeon perfect security, for it permits him to verify his own impressions. When a pericardial effusion has been evacuated and the finger exploring the sac does not encounter the projectile, an inspection with the "bonnet" gives immediate information as to its presence or its absence. If it is a question of extracting an intra-cardiac foreign body, the surgeon, before making an incision in the wall, examines whether the form of the mass which he holds between his fingers corresponds to the projectile. Finally, if the projectile becomes displaced (and cases of unexpected migration have been noted), radioscopy is of great value.

The last stage of the operation is also facilitated by the fluoroscope. The roentgenologist guides the operator in taking the projectile with the forceps and after the removal he searches for any fragments of metal that may remain.

Radiology, therefore, plays a part of primary importance in diagnosing, localizing war projectiles in the heart, and facilitating the different stages of surgical extraction.

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